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ORIGINAL ARTICLES.

I.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from the June Number, p. 243.*)

PLATE XIV.

Membranipora fascelis, sp. nov. (Pl. XIV, Figs. 1, 2.)

Zoarium unilaminate, adherent.

Zoœcia fairly large, with very little external front wall; areas widely elliptical, flattened for a short way at the upper end and surrounded by a slender rim, average length ·5 mm., breadth ·35 to ·4 mm.

Oœcia very constant in occurrence, semicircular in plan, borne on the very scanty front wall of the succeeding zoœcium and often impinging slightly on its area.

Avicularia very numerous, nearly always small and interstitial, but occasionally (Fig. 2) large and vicarious or sub-vicarious, very uniformly well preserved; they are of hour-glass type, short and wide, and the ends of a crossbar occur about one-third of the way up the aperture; these ends are so sharp and uniform as to suggest that they are not the remains of a broken calcareous bar but the well-preserved supports of a membranous bar.

This species occurs sparingly in the zone of *M. cor-anguinum* in Hants and Kent, and I have a dwarfed specimen from the zone of *Marsupites* in Hants. It seems to form a lineal series with the three following.

Membranipora faustina, sp. nov. (Pl. XIV, Fig. 3.)

Zoarium unilaminate, adherent.

Zoœcia large, shallow, and entirely devoid of front wall, which gives them a very primitive appearance, very variable in shape, and often developing a long narrow handle at the lower end which in a less primitive form would be a very probable mark of avicularia; ·6 mm. would perhaps be a fair average length of area, apart from the handle-like extension which may add almost any length to the zoœcia in which it occurs; at the lower end there is very regularly developed a crescent-shaped to semicircular cavity in the floor which may be oœcial in nature.

Oœcia do not occur.

Avicularia numerous, of the same general type as those of *M. fascelis*, but smaller and in proportion much narrower; they are

always interstitial and sometimes impinge sharply on the adjoining zoœcia.

This species occurs in the zone of *M. cor-testudinarium* in Hants, and probably in those upper beds which for Dr. Rowe are the lower fourth of the zone of *M. cor-anguinum*. I have only one specimen, and should not have described it but for its apparent serial relationship to *M. fascelis*.

MEMBRANIPORA FERONIA, sp. nov. (Pl. XIV, Fig. 4.)

Zoarium unilaminate, adherent.

Zoœcia definitely pyriporiform, with a long and generally very slender tapering external front wall; areas narrowly elliptical, average length ·45 to ·5 mm., breadth ·27 mm., separated from the external front wall by a slender but definite rim.

Oœcia wide and slightly heel-shaped in ground-plan, not numerous.

Avicularia much like those of *M. fascelis*, even to the occasional vicarious specimens, but smaller, and in proportion much narrower, and placed centrally above the zoœcia as a rule; the crossbar is undoubtedly calcareous, being frequently preserved; it divides the aperture into two nearly equal parts, the upper being slightly the larger.

This species is rare in the zones of *A. quadratus* (restricted) and *B. mucronata* in Hants. It closely resembles *Reptoflustrella ovalis*, D'Orb.,[1] the only clear distinction lying in the avicularia, which in *R. ovalis* are smaller, quite different in shape, and devoid of any suggestion of crossbar; but the resemblance can only be accidental if Canu is right in identifying the latter species with *Semiflustrella rhomboidalis*, D'Orb.,[2] which is palpably distinct from *M. feronia*.

MEMBRANIPORA FLACILLA, sp. nov. (Pl. XIV, Fig. 5.)

Zoarium unilaminate, adherent.

Zoœcia feebly pyriporiform, with very short and rapidly tapering external front wall; areas distinctly large, length ·55 to ·65 mm., breadth ·38 to ·4 mm., elliptical and definitely flattened at the upper end, and separated from the external front wall by a faint rim; just outside the two corners formed by the flattening of the upper end a pair of pores occurs very regularly in a swelling of the rim.

Oœcia broad and slightly heel-shaped in ground-plan, fairly numerous.

Avicularia corresponding almost exactly with those of *M. feronia*; the ends of the crossbar are about half-way up the aperture.

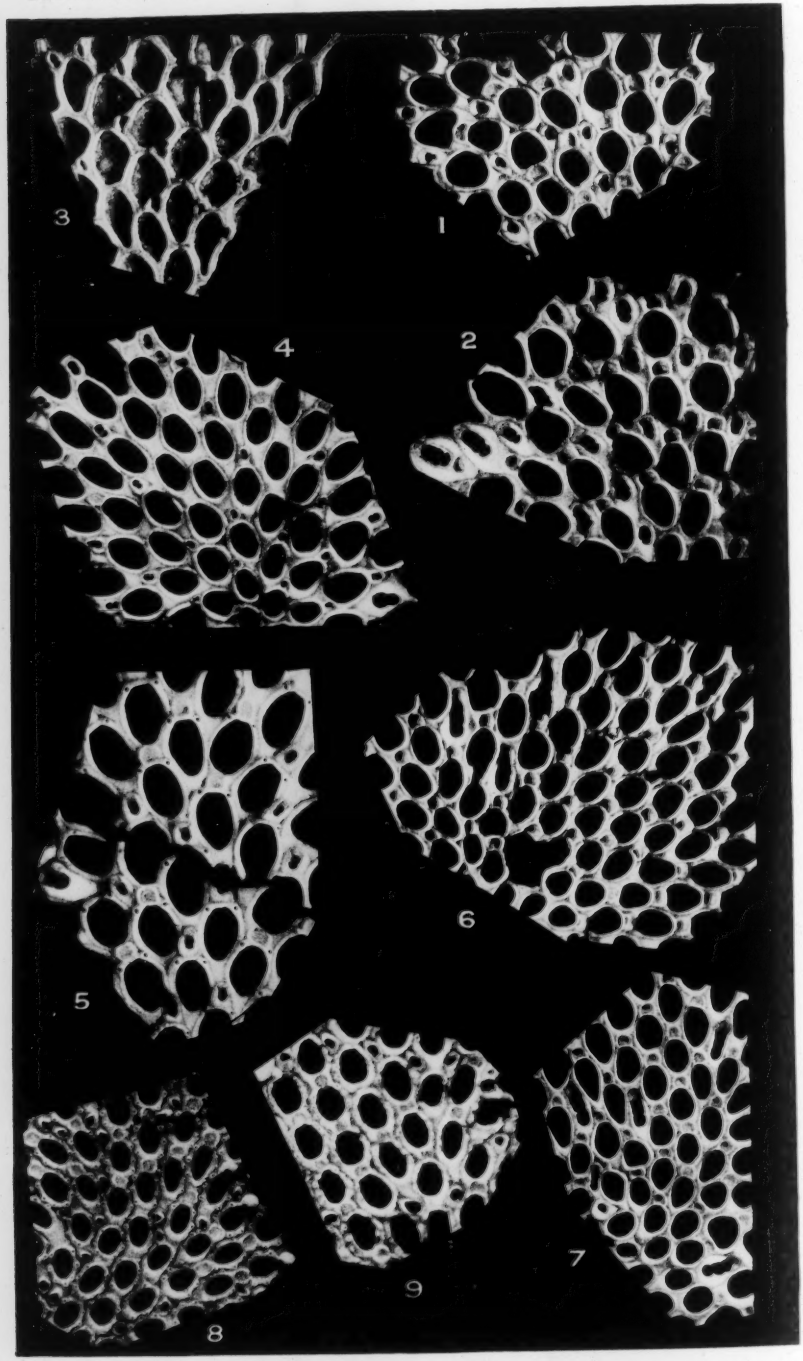
This species is rare in the Weybourne Chalk (zone of *B. mucronata*), and is apparently the last of the English series, as I have not met any representative in the Trimingham Chalk.

MEMBRANIPORA FLAMMIA, sp. nov. (Pl. XIV, Figs. 6, 7.)

Zoarium unilaminate, adherent.

Zoœcia rather small, the initial zoœcia of new rows feebly pyriporiform, more as it were of necessity than by choice; areas in the

[1] Pal. Terr. Crét. Franç., v, p. 571, pl. 731, figs. 17, 18.
[2] Ibid., p. 564, pl. 730, figs. 5–8.



R. M. Brydone, Photo.

CHALK POLYZOA.

early stages slightly oval, but in the later stages often truly elliptical, and ranging in length from ·35 to ·5 mm.

Oœcia very abundant, borne upon a scanty front wall provided by the succeeding zœcium at the expense of a broadening and flattening of the lower end of its area, which emphasizes, if it is not indeed the sole cause of, the oval shape; they are globular with a definitely concave free edge, but in the later stages the ground-plan tends to become narrowly heel-shaped.

Avicularia vicarious, of hour-glass type, but much elongated and in the lower part rather expanded and inflated; the remains of the crossbar occur about one-third of the way up the aperture, and apparently spring from the infolded walls at the lower point where they reach the aperture at which they cause a slight constriction of its apparent outline; there is a faint tendency to a similar constriction at the corresponding upper point.

This species occurs sparingly in the (restricted) zone of *A. quadratus* in Hants. It seems rather isolated.

MEMBRANIPORA FLORA, sp. nov. (Pl. XIV, Figs. 8, 9.)

Zoarium unilaminate, adherent.

Zoœcia rather small, with thick areal margins rising out of a common crust; areas broadly to narrowly elliptical, average length ·35 to ·4 mm., breadth ·18 to ·28 mm.; the areal margins bear three or four pairs of perforated tubercles.

Oœcia globular, with fairly wide aperture and deeply concave free edge.

Avicularia abundant, interstitial, small mandibular with calcareous crossbar, a good deal tilted up on the lower end.

This species occurs sparingly in the zone of *M. cor-testudinarium* at Seaford. The tilted-up avicularia are somewhat suggestive of affinity with the group of which *M. cuculligera*, Bryd.,[1] is a typical member.

EXPLANATION OF PLATE XIV.

(All figures × 12 diams.)

FIG.

1, 2. *Membranipora fascelis*. Zone of *M. cor-anguinum*. Gravesend.
3. *M. faustina*. Zone of *M. cor-testudinarium*. Basing, Hants.
4. *M. feronia*. Zone of *A. quadratus* (restricted). Shawford, Hants.
5. *M. flacilla*. Zone of *B. mucronata*. Weybourne.
6, 7. *M. flammia*. Zone of *A. quadratus* (restricted). Shawford, Hants.
8, 9. *M. flora*. Zone of *M. cor-testudinarium*. Seaford.

(To be continued.)

II.—On some Deposits containing an Arctic Flora in the Pleistocene Beds of Barnwell, Cambridge.

By J. E. MARR, Sc.D., F.R.S., and Miss E. W. GARDNER, Harkness Scholar, Newnham College, Cambridge.

ONE of us has been engaged for some years in the study of the Pleistocene gravels and associated deposits of the Cambridge district, and eventually proposes to give a full account of the results obtained. Meanwhile, considering the importance of noting the

[1] GEOL. MAG., 1914, p. 481, Pl. XXXV, Figs. 1, 2.

conditions under which Pleistocene floras are preserved, in order to draw attention to their probable occurrence under similar conditions elsewhere, it is thought advisable to give a preliminary account of the discovery of an Arctic flora of this date in a pit at Barnwell, a suburb of Cambridge, long noted for its Pleistocene deposits.

The pit in which the plant-seams are exposed is situated to the west of the railway, close to Barnwell Station. The section in this pit was described and figured by the late Mrs. McKenny Hughes in the Geological Magazine for 1888 (Dec. III, Vol. V, pp. 194–6), and the figure is reproduced with slight alterations in Professor Hughes' recently published paper, "The Gravels of East Anglia" (Cambridge University Press, 1916). The section has been much enlarged in the last few years, and at present there is a continuous exposure with a length of about 500 feet along the north pit-face in a direction nearly east and west, that is, at an angle of about 45° to the section given in Mrs. Hughes' paper.

Along this line of section the beds are very even and approximately horizontal, thus showing a contrast to the unevenly bedded deposits figured in the papers cited. These uneven beds are still seen in a face nearly at right angles to the present long face. In this shorter face the base of the deposits is seen to rise towards the south, that is, in the direction of the Newmarket road.

The even- and uneven-bedded deposits belong to the same series, and indeed the one set passes into the other. The uneven-bedded set was deposited against a slope, and where the bedding becomes more even, indications point to deposition on a flatter floor.

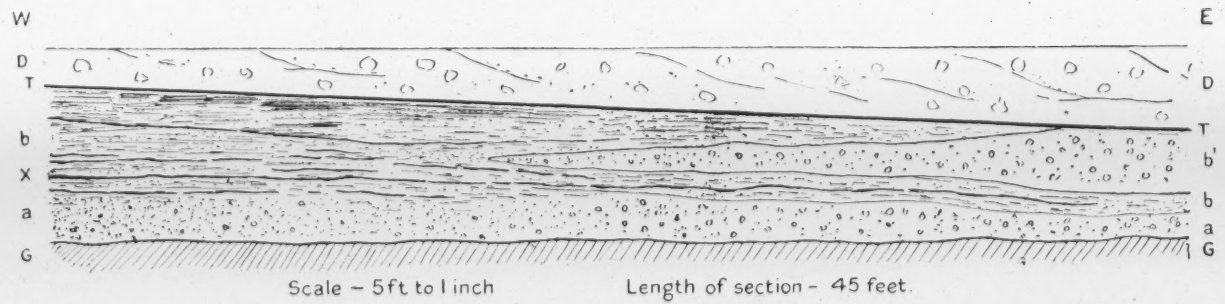
The following section is a representation of the beds towards the western end of the north face. It is in this part of the face that the peaty seams are most abundant and the bedding most even. The section shows clearly that the peaty seams are part of the Pleistocene strata and not deposits of later date banked up against them. The section as figured is about one-tenth of the length of the whole northern face along which the beds are now clearly seen.

The gravels are not very coarse, and some sand beds are seen among them. The loams vary in coarseness, some being sandy, others more clayey. The peaty bands, varying in thickness from one-eighth to half an inch, consist of loamy peat, from which good specimens of leaves, seeds, etc., are readily extracted. Where best developed there are at least five layers of these seams seen in vertical section. The plants hitherto obtained were extracted from the most persistent seam, which is the lowest but one. The section shows the manner in which the various seams die out laterally.

We obtained abundant leaves of a plant which we regarded as *Betula nana*, and Mr. Clement Reid, F.R.S., who kindly examined our plants, has confirmed this, and in a preliminary list has noted the presence of several additional Arctic forms. There is therefore no doubt that we have here another addition to the Pleistocene Arctic beds of this country.

We do not propose to discuss at present the relationship of this low-level series of deposits to the other Pleistocene accumulations of the district, but content ourselves with stating that their mode of

SECTION ALONG NORTH FACE OF BRICK-PIT, BARNWELL STATION.



D, disturbed and resorted gravel of old workings; *b'*, wedge of gravel in *b*; *b*, clayey and sandy loams with plant-bearing peaty layers. The peaty layers are indicated by dark lines. The plants were obtained from the layer *x*. *a*, gravel becoming finer to the west; *G*, Gault; *T*-*T*, line of tramway.

occurrence, quite apart from the low level, which is in itself of no great significance, is in favour of their reference to one of the latest, if not the latest stage, of the Pleistocene deposits of the district.

In addition to the plants the peaty seams have furnished several remains of insects, and the following shells, which are all of species recorded by Mrs. Hughes from the beds of the pit: *Planorbis spirorbis*, *Succinea oblonga*, *Helix hispida*, and *Pupa marginata*. Others will no doubt be added when the deposits are worked in greater detail.

No mammalian bones have yet been found in the peaty material, but Mrs. Hughes records *Cervus elaphus*, *Elephas primigenius*, *Equus caballus fossilis*, and *Rhinoceros leptorhinus* or *tichorhinus* from the pit. We have recently obtained the horse, the mammoth, the reindeer (*Cervus tarandus*), and an ilium of *Rhinoceros tichorhinus*. These were determined by Mr. C. E. Gray, the First Attendant in the Sedgwick Museum. We are satisfied that these bones came from the pit, though obtained from workmen. These workmen offer for sale various objects from the gravel and Gault, and in no case has any attempt been made to dispose of objects clearly brought from elsewhere.

Since writing the above we have found among the bones deposited in the Sedgwick Museum fragments of antler collected from this pit in 1888, which are recorded on Mr. Gray's authority as *Cervus tarandus*.

No worked flints of any importance have yet been found. A flake with platform and bulb may have been derived. In any case it gives no clue as to age, and we may make the same remark about half a dozen spalls (flakes) with bulbs which have been picked up.

The occurrence of the base of the Pleistocene deposits of this pit at a depth of about 6 feet below the surface of the alluvium of the Cam which abuts against them is a fact of considerable importance. As the base of the gravel further south is some feet above the surface of the alluvium and is falling northwards, the existence of a deeper buried channel below the alluvium is probable, and receives support from a section figured by Professor Hughes in the paper cited (fig. 26) and from the accompanying account of the deposits. He states that "the Jesus College gravel with mammoth runs to a depth of some 30 feet below the lower end of Maid's Causeway" to which the alluvium extends. These Jesus College gravels occur under similar conditions to those at Barnwell Station, which is only a mile distant down the river. They are therefore probably of the same age, and it is certain that in each of these two sections we have Pleistocene deposits below the level of the surface of the modern alluvium. The actual centre of the channel may well lie further under the alluvium, and extend to a greater depth below its surface than the 30 feet recorded in the case of the Jesus College gravel. The situation of our plant-bearing deposits therefore recalls that of the Arctic Plant Bed of the Lea Valley described by Mr. S. Hazzledine Warren (Quart. Journ. Geol. Soc., vol. lxviii, p. 213, 1912, and vol. lxxi, for 1915, published 1916, p. 164.

In the case of the Lea Valley deposits, the lowest terrace in which

the plant-beds occur appears, according to Mr. Warren's account, to be cut through by the buried channel, whereas the evidence at Barnwell is in favour of the view that the beds belong to the deposits filling a channel of that nature. Whether that be so or not, the significant feature is the similarity of the floras of the two districts. Mr. Reid permits us to state that in the case of the Barnwell beds "the assemblage is essentially that of the Lea Valley".

The occurrence of this flora in low-level gravels in the Lea and Cam Valleys encourages us to hope that it will be discovered elsewhere, and it is very desirable that the lowest Pleistocene gravels of other river-valleys should be examined for similar deposits.

III.—New Extinct Bird from South Carolina.

By R. W. Shufeldt.

(PLATE XV.)

EARLY in January, 1916, Dr. O. P. Hay, of Washington, D.C., referred to me for description the fossil bone of a large bird that had been discovered in the eastern part of South Carolina some time previously. This specimen I at once recognized as the lower extremity of the right femur of some bird belonging to a species much larger than any existing form in the United States. I find this specimen to be thoroughly fossilized and of a dull-black colour, the edges of both condyles being considerably chipped off. On the antero-internal aspect the shaft appears to be cut away as if by some shaving implement. This, and where the shaft is broken nearly squarely across above, exposes a filling of a dense, very hard, pale-grey matrix, with a grain as fine as clay. Judging from this there should be no doubt but that this femur was a thoroughly pneumatic one in the living bird, and that the thickness of the osseous wall of the shaft was by no means great, as may be appreciated by examining the figures on the accompanying Plate XV.

Upon measuring, I find the extreme length of this specimen to be 75 millimetres, and its greatest transverse width below (intercondylar), 40 millimetres. Antero-posteriorly, the external condyle measures 25 millimetres (the inner lip of the fibular cleft), and the corresponding diameter of the inner condyle is about the same. No especial effects of pressure or distortion from the same mark this fragment, which is, in every particular, quite typically ornithic in character. Superiorly, the shaft is nearly cylindrical; but, immediately below the point of fracture, begins to expand and to become, antero-posteriorly, flattened and much broadened, until it terminates in its condylar enlargements. In front, the intercondylar or "rotular channel" does not extend up the shaft beyond the condylar ridges, while posteriorly the popliteal area exhibits but little concavity, the whole being much in the same plane. There is, however, an independent excavation immediately above the internal condyle upon this aspect of the bone.

The external condyle is subcircular in outline upon its outer aspect, while the usual fibular cleft or notch is deeply impressed upon its posterior aspect (Fig. 4).

Passing to the internal condyle, we find that it too is, upon lateral aspect, subcircular in outline, its postero-superior termination being produced upwards in a more or less prominent way, behind the above described independent excavation (Fig. 1). The intercondylar valley averages about 7·5 mm. in width, being concave from side to side, and convex in the opposite direction. This fragment weighs 2½ oz., and has been marked with a red capital letter S on its anterior aspect immediately above the intercondylar valley. From this I am assured by Dr. Charles Schuchert, Curator of the Geological Department of the Peabody Museum of Yale University, in his letter to me of February 25, 1916, that the specimen belongs to the "Scanlon Collection, and it has been loaned to Dr. Hay".

As to the formation from which this specimen came, I would say that Dr. Hay believed it to be Miocene, and this was also the opinion of Dr. Vaughan, of the U.S. Geological Survey, who likewise kindly examined it for me in February, 1916. It presents the general appearance of fossil bones of vertebrates from that horizon, and the question seems to be definitely settled by Dr. Earle Sloan, of Charleston, South Carolina, who says in his letter to Dr. Hay of February 29, 1916, in reference to these phosphatic fossils from the Stono River, South Carolina, near its source, whence the present specimen came, that "Nearly all of the vertebrate fossils (many of the cetacea and squalidae excepted) are junior in origin to the phosphate bed, the cavernous interstices of which they entered with their associate supernatant ooze (described as Salkehatchie Ooze), which purely from stratigraphic relations I regard as of late Miocene origin.

"In this connection I beg leave to refer you to my Mineral Catalogue, pages 330 to 336. Also to page 472, which relates to the phosphatic ooze designated the Salkehatchie Ooze.

"The Scanlon fossil collection was in the main taken from the rock dredged from the bed of the Stono River near its source, or about fifteen miles from the present coast line of the Atlantic, but coincident with the old shore line of the Middle Miocene.

"The Mastodon teeth presented by me to the Museum were dredged from the bed of the Coosaw River, which represents the former wide estuarine area of several minor streams, most of which was subsequently covered by the Salkehatchie Ooze and subsequent sediments, marshes, etc.

"The Mio-Pliocene beds enclose many reworked rounded fragments of the senior phosphate bed, but have nowhere been observed underlying Salkehatchie Ooze; therefore it is my opinion that the greater portion of the vertebrate remains in contact with the Old Miocene phosphate beds are late Miocene."

On February 6, 1916, at the U.S. National Museum, I compared this fragment of the lower end of the right femur with the corresponding part of that bone belonging to birds of many groups existing in North America, and also with a number in my own collection of avian skeletons, as well as with certain fossil femora figured by me in my "Review of the Fossil Fauna of the Desert Region of Oregon,

with a description of additional material collected there".[1] In that work I figure, on pl. xxxvi, fig. 431, the left femur of *Olor paloregonus*, Cope, natural size, anterior aspect, which is as big as an anserine fowl when it existed, but was very little more than half the size of the bird the femur of which I am now describing.[2] For example, I compared this fossil with the right femur of the Secretary Bird of Africa, with *Pandion*, with several eagles, with *Vultur monarchus*, and with various owls of large size, but very marked characters distinguished it from the lower end of the femora of any of these birds. In other words, this fossil femur did not belong to any genus, near or remote, of the *Striges*, nor to a diurnal representative of the Raptores. For similar reasons it could not be classed among the Cathartidæ, as a careful comparison with the femur of the Condor of South America and with the corresponding bone of the California Vulture (*Gymnogyps californianus*) showed very distinctive differences. Both the Condors and the Secretary Bird possess a marked excavation in the popliteal space above the condyles; while in *Vultur* the external lip of the fibular notch is, superiorly, drawn out into a somewhat conspicuous little process. This process is very well developed in several, if not in all, of the North American eagles.

Somewhat similar differential characters demonstrated the fact that this fossil femur never belonged to any bird at all related to *Sula*, or to any of the herons, or to *Pelecanus*, all of which have femora possessed of some characters, which, though not of wide difference, are quite sufficient to constitute discriminating ones, and to point to the fact that this great extinct fowl did not belong in any of those groups, as we now know them, osteologically.

This fossil end of a femur possesses no marked characters that point to any relationship with any large gallinaceous bird—still less to any struthious form, as an ostrich or the like. With negative results, I also compared it with the femur of various species of the Phalocrocoracidæ, the Phœnicopteridæ, and the Colymbidæ and their congeners. It belonged to a big bird, having no especial affinities with any of these, certainly not with any of the great toothed loons of the Cretaceous.[3]

Passing to the *Anseres* and to certain of their allies, near and remote, it at once appeared that certain characters in the specimen under consideration presented very evident points of agreement. In a specimen of *Olor buccinator* (No. 18509) at the National Museum, the femur appears to be non-pneumatic. This is a skeleton I prepared myself many years ago in New Mexico, where I had no facilities for thorough cleaning, and it is just possible that the femur may be, to some extent, pneumatic. There is a skeleton of *Branta canadensis* in the same collection that appears to be to a degree pneumatic. This would, apparently, be contrary to certain previous statements

[1] American Museum of Natural History Bulletin, vol. xxxii, art. vi, pp. 123–78, New York, July 9, 1913; see pl. xxxvi, fig. 431.

[2] E. D. Cope, Bull. U.S. Geol. and Geogr. Surv. Terr., iv, pp. 387–9, 1878.

[3] O. C. Marsh, *Odontornithes*, pl. xiii, figs. 1–4.

of mine in some particulars, but not in all; in any event it would not invalidate the evident resemblance and certain actual agreements of this fossil specimen with the thigh-bone of several anserine genera and others remotely related to them.[1]

In *Chauna torquata* the femur is very pneumatic, and this bird has long been suspected of having certain relationships with the *Anseres*, as have the Palamedeiformes generally.[2] The general facies of the femur of *Chauna* bear not a little resemblance to the specimen in hand, though in the first-named bird the rotular channel is relatively deeper. The external condyles in the two are very similar. This likewise applies to *Olor* and to other swans, but to *Branta* and other genera of geese to a somewhat lesser degree.

In other words, as far as this fossil fragment of a femur will carry us, I am of the opinion that it belonged to the skeleton of some very large, generalized, anserine bird, which existed, during late Miocene times, in the eastern section of this country and probably elsewhere. As far as the fragment carries, it confirms the affinity of the Screamers (Palamedeiformes) with the *Anseres*, but it throws no light upon the anserine affinities of the Flamingoes.

Inasmuch as we have already discovered the fossil remains in this country of such ponderous swan and goose species as *Anser condoni*, Shuf., and *Olor paloregonus* (Cope), it should not surprise us to find even bigger ones than these; in my opinion we have one here. Others of large size represent the extinct Gastornithiformes in other parts of the world.[3]

Confining ourselves to America—although it is doubtless also true of the extinct avifaunæ of all countries—I may say here that when we find fossil birds in a formation as early as late Miocene, and they are of comparatively large size, it is just possible—indeed, quite probable—that, in the case of some of them, they may represent an ancestral type, from which has descended several branches to be represented in the existing avifauna. Upon the extinction of the early ancestral stock, it is often very puzzling to conjecture what the true relations of the forms, genera, and families in existence may be that were derived from the aforesaid ancestor or ancestors. It is not at all unlikely that the fossil here described may be the ancestral type of several groups still in existence in this country or in the Americas. In this connexion it would be well to bear in mind the possible relationships of the *Anseres*, the Palamedeiformes, the Phœnicopteridæ, and others.

Finally, the fossil I have here described appears to be not unlike

[1] R. W. Shufeldt, "Osteology of Birds": New York State Education Department, State Museum Bull. 130, 1909, pp. 330–40. Attention is especially invited to what I say on p. 335 as to the femur in *Branta* agreeing with that bone in *Olor*. There are, of course, certain minor swan and goose characters of this bone, which can be both recognized and appreciated, and which would properly fall in the category of "general and special characters"; otherwise, the statement there made will hold good.

[2] R. W. Shufeldt, "An Arrangement of the Families and Higher Groups of Birds": *Amer. Nat.*, vol. xxxviii, Nos. 455–6, pp. 833–57, Nov.–Dec., 1904.

[3] R. W. Shufeldt, ibid., p. 337.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

DISTAL PART OF RIGHT FEMUR OF EXTINCT BIRD FROM SOUTH CAROLINA.

the one I figure in another connexion, that is, fig. 74 of pl. lvii of my paper, "Further Studies of Fossil Birds, with Descriptions of New and Extinct Species": Amer. Mus. Nat. Hist. Bull., N.Y., vol. xxxii, art. xvi, p. 290, August 4, 1913.[1] The bone there figured is of a *left* femur, while the one described in the present article is from the *right* pelvic limb; and in so far as I am able to judge from the cited fig. 74 the two bones are wonderfully alike, both in the matter of form and proportions. Unfortunately, the femur shown in fig. 74 is so firmly fixed in its flinty matrix that the popliteal area cannot be examined properly. To all appearances, however, the femoral condyles were of the same size and form; and had I had these two specimens together at the time the bone in fig. 74 was described, it is quite possible that, by the aid of the greater number of exposed characters in the specimen described in the present article, I would have referred them both to the same species, or at least to the same genus. In fact, the Miocene types of both the gallinaceous birds and the anserine ones may have had not a few osteological characters in common.

For this extinct and probably largest anserine bird discovered in America up to the present time, I here propose the name of *Palæochenöides mioceanus*,[2] gen. et sp. nov.

In preparing this account I am indebted to Dr. O. P. Hay for various courtesies extended to me during the time the material was in my possession; to Dr. Earle Sloan, of Charleston, S.C., for information with respect to the discovery of the specimen and the formation to which it belongs; and to Mr. J. H. Riley, of the Division of Birds of the U.S. National Museum, for assistance in selecting bird skeletons in the collection of that institution for comparison with the material in hand.

EXPLANATION OF PLATE XV.

FIG. 1.—Direct outer aspect of the distal part of the right femur of *Palæochenöides mioceanus* (extinct). All the figures are natural size, and are reproductions of photographs of the specimen made by the author.

,, 2.—The same bone on direct inner side view. Here the specimen is slightly tipped toward the observer in order to show the matrix filling the thin, hollow shaft. This tipping causes Fig. 2 to be somewhat shorter than the other figures.

,, 3.—The same specimen viewed directly from in front.

,, 4. ,, ,, ,, behind.

[1] I am not responsible for the title given pl. lvii of that paper; and on the page cited I say that it appears to have been a gallinaceous fowl, but that the material does not admit of a scientific reference.

[2] Generic name = Gr. παλαιός = ancient, + χήν, a goose, + οειδής, having a resemblance to, or, in other words, having the general characters of, some of the very early ancestors of the anserine birds. Sp. = Gr. μείων = less, + καινός, recent: a subdivision of the Tertiary named by Lyell.

IV.—The Crystalline Rock-areas of the Piémontese Alps. II. Northern Piémont.

By C. S. Du Riche Preller, M.A., Ph.D., M.I.E.E., F.G.S., F.R.S.E.

(*Concluded from the July Number, p. 313.*)

III. The Lanzo, Ivrea, and Val Sesia Area. (Figs. 1[1] and 4.)

THIS, perhaps the most complex crystalline area of the Piémontese Alps, is also eminently *sui generis*, for it forms a unit of rocks outside, and different from the great calc-schist horizon with pietre verdi of secondary composition. As previously stated, it is the continuation of the mica-schist and minute gneiss belt which skirts the Po Valley from the Rocciacorba group to Avigliana, Monte Musiné, and Lanzo, and, extending from Lanzo to Ivrea, Biella, and Val Sesia, reaches beyond the latter into Lombardy to Lakes Orta and Maggiore. Within the Piémontese Alps, viz. from Lanzo to Val Sesia, it is bounded on the north by the calc-schist and pietre verdi fringe which skirts the Monte Rosa gneiss massif, and on the south by the Pliocene and Pleistocene deposits of the Po Valley, its superficial area being roughly 90 by 15 kilometres or 1,350 square kilometres, equal to over 500 square miles. The lower hills of the southern margin vary from 600 to 900 metres in altitude, which in the centre of the area increases to 1,000 and at the northern margin to 2,500 metres. In its general direction south-west to north-east, the area is intersected more or less at right angles by the following affluents of the Po: Stura di Lanzo, Malone, Orco, Chiusella – Dora Baltea, Elvo–Cervo, and Sessera–Sesia. The valley floors vary at the lower limit of the crystalline area from 300 to 500, and in their upper parts from 600 to 1,000 metres in altitude.

As distinguished from the crystalline schist and pietre verdi zone of the Maritime, Cottian, and Grajan Alps, Gastaldi labelled the Lanzo–Val Sesia area the "external crystalline zone".[2] Gerlach,[3] as early as 1869, designated it as the Ivrea dioritic zone, from the conspicuous outcrops of diorite within and outside the great morainic amphitheatre of the Dora Baltea Valley around Ivrea, which town is itself built on diorite.[4] Within recent years it has come to be called the dioritic-kinzigitic zone, chiefly in consequence of Franchi's and Novarese's surveys,[5] and in order to give due prominence to the

[1] [The text-illustration (Sketch-map) given in the previous part (p. 306) is largely referred to here in the second part of this paper.—Ed. Geol. Mag.]

[2] Gastaldi, "Studi geol. Alpi Occid.": Boll. R. Com. geol., 1871, p. 3 et seq.

[3] Gerlach, *Die Pennischen Alpen*, 1869.

[4] The lakelets S. Michele, Campagna, Sirio, Pistone, and Nero immediately north of Ivrea, near Montalto, within the moraine wall of Serra d'Andrate, all lie in the diorite zone.

[5] C. F. Parona, "Valsesia e Lago d'Orta": Atti Ist. Lomb., vol. xxix, Milano, 1886. V. Novarese, "Trattato Weinschenk Zona d'Ivrea": Boll. R. Com. geol., 1905, p. 181 et seq.; "Zona d'Ivrea": Boll. Soc. geol. ital., 1906, p. 176 et seq. S. Franchi, "Zona dioritica-kinzigitica Ivrea-Verbano": Boll. R. Com. geol., 1906, p. 270 et seq.; "Anfibolo secondario del gruppo glaucofane in una diorite di Val Sesia": ibid., 1904, p. 242.

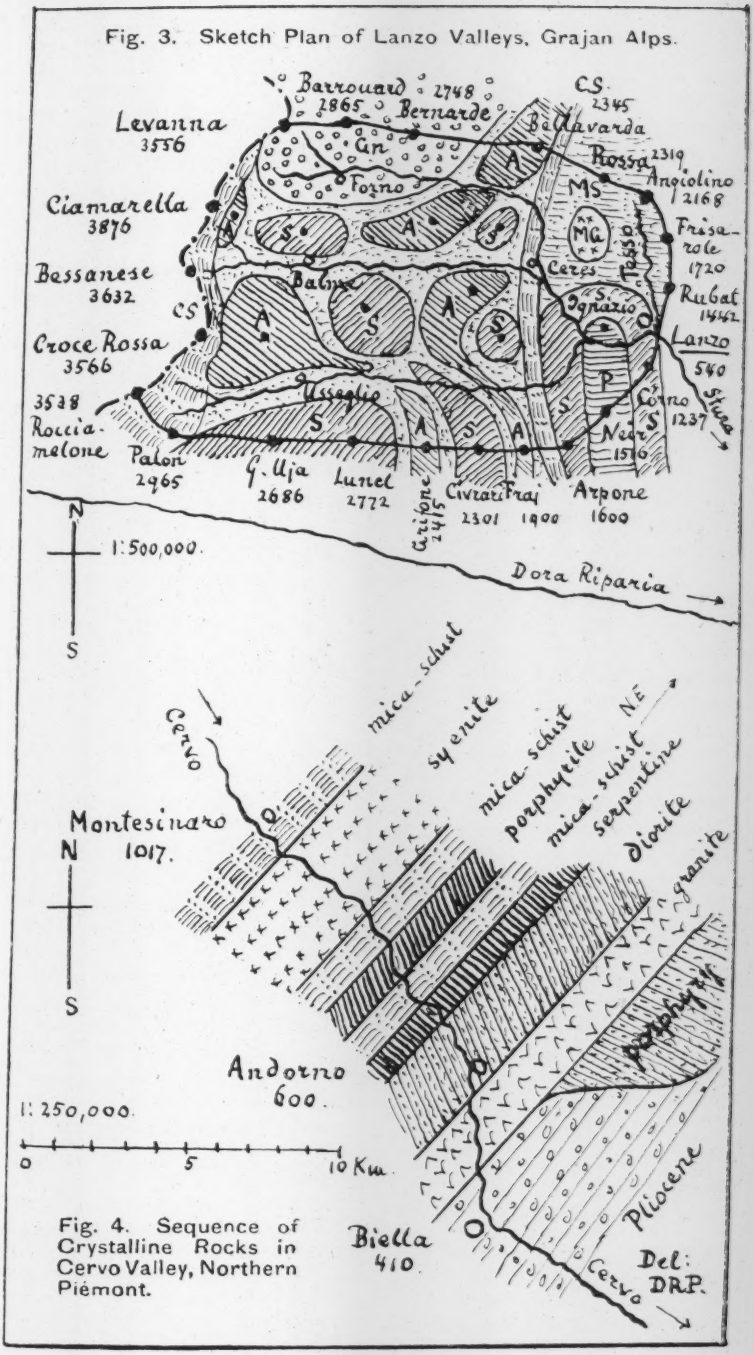


Fig. 3. Sketch Plan of Lanzo Valleys, Grajan Alps.

Fig. 4. Sequence of Crystalline Rocks in Cervo Valley, Northern Piémont.

Fig 3. S = serpentine; A = amphibolites, prasinites and euphodites; P = peridotite and lherzolite; CS = calc-schist; MS = mica-schist.

eclogitic gneiss formation in the Sesia Valley and east of the same, which has its equivalent in the Kinzig Valley of the Black Forest, where it was first recognized and so named by Fischer as early as 1863. Another equivalent formation is that of the hilly area near Monteleone, bordering on the Mediterranean in Calabria.[1] In all the three cases, the rock, greenish brown in colour, gneissic in aspect and structure, but more fine-grained, micaceous, and less quartzose than primitive gneiss, is often granitoid, and, besides triclinic felspar and quartz, contains garnet, omphacite, biotite, sillimanite, and graphite as associated minerals.

From Lanzo to Val Sesia, the sedimentary crystalline formation concomitant with the Sesia gneiss is that of eclogitic mica-schists, viz. with garnet, omphacite, and blue glaucophane, corresponding to those of the Aosta Valley.[2] With the mica-schists and occasional minute gneiss intercalations are associated dark-greenish, sericitic, calcareous, and quartziferous Permian schists. Both are overlain here and there by isolated masses or patches of Lower Triassic, more or less crystalline and dark dolomitic limestone, the remnants of a much more extensive formation removed by denudation. In the mica-schist formation are intercalated—

(1) The continuous belt of biotitic and amphibolic diorite which covers 50 by 5 to 10 kilometres in length and width, and is flanked on its southern margin by granite, and on its northern margin by minor belts of peridotite, serpentine, and biotitic and pyroxenic porphyrite.

(2) Isolated masses of gabbro, peridotite and lherzolite, granite, syenite, and porphyry.

The coarse-grained gabbro and the peridotitic masses together with those of granite and syenite, associated with minute gneiss and mica-schist, are prevalent more especially in the hills between Lanzo and Ivrea, where a number of interesting, mostly quarried exposures occur at Balangero, Corio, Levone, Rivara, Cuorgné, Belmonte, Locana, Vidracco, Castellamonte, Baldiserro, Muriaglio, Lessolo, and Traversella, in and between the Malone, Orco, and Chiusella Valleys at levels from 400 to 800 metres altitude. Extensive masses of granite and syenite also crop out north of Biella in the Cervo Valley, while east of Biella to Val Sesia and Lake Orta runs, parallel to the diorite belt, a continuous belt of grey and reddish granite 2 to 4 kilometres in width, flanked on the south by a large lenticular mass of red porphyry which extends to Borgosesia in the lower Sesia Valley and thence to Lake Maggiore.

[1] R. Ugolini, "Kinzigite di Monteleone, Calabria": Atti Soc. toscana Pisa, 1911, p. 55 et seq.

[2] The eclogitic mica-schist formation with pietre verdi has revealed a considerable variety of jadeitic and jadeitoid rocks which S. Franchi, V. Novarese, and A. Stella discovered both in nodules and blocks in situ and as pebbles in the alluvia of rivers in various parts of the Piémontese Alps. These eclogitic and chlorito-melanitic rocks correspond with the Neolithic implements of Piémont, thus proving the latter to be, not exotic, but indigenous. "Nuovi Giacimenti roccie giadetiche": Boll. R. Com. geol., 1900, p. 119; Boll. Soc. geol. ital., 1903, pp. 130, 135, 141.

The great diorite belt begins near Castellamonte (408 m.) in the Orco Valley, about midway between Ivrea and Lanzo, crosses the Dora Baltea at Ivrea (267 m.), Montalto and Bio, continues north-east to Donato, Ceresito, Graglia, Pollone, and Biella (410 m.), traverses the Cervo Valley at Andorno (600 m.), and thence extends to Val Sesia between Varallo (450 m.), Scopa, and Scopello (650 m.). From Donato, close to the great eastern moraine wall or Serra d'Andrate, the diorite is flanked on the left by serpentine and porphyrite belts, each about 1 kilometre in width, which extend for about 20 kilometres to the Sessera Valley, midway between the Cervo and Sesia Valleys.

In all these isolated and continuous masses of basic and acid eruptive rocks the structure is prevalently massive and granitoid, rarely schistose, with essentially primitive elements without alteration by metamorphism. Peridotite and lherzolite are much more in evidence than the altered product serpentine. The granite with white and pink felspar, very little mica, but rich in quartz, is made up of smaller elements than ordinary granite. Both it and the syenite masses of Traversella and Biella are closely related to the diorite which at Pollone, near Biella, becomes micaceous, then quartzose, and then passes into granite. The greenish-grey granitoid diorite with hornblende and biotite, often garnetiferous, is essentially massive and unaltered; only in contact with peridotite or gabbro is there an occasional tendency to prasinitic alteration by decomposition, but without contact metamorphism. The dioritic and porphyrite belts, although running parallel for 20 kilometres, are nowhere in direct contact, but always separated by a band of serpentine, mica-schist, or sericitic, quartziferous schist. The porphyrite (Gastaldi's melaphyre) contains occasionally, e.g. near the Oropa Sanctuary above Biella, lenticular blocks of mica-schist, the former thus having probably consolidated somewhat later than the latter. The sericitic, quartziferous schist is of the same greywacke type as that flanking the diorite belt of Gran Nomenon and of Val Cogne in the Aosta Valley. Between those two diorite belts, linked by the intermediate diorite mass of Locana in the Orco Valley, there is, as already mentioned, obviously a zonal connexion. The locality of Locana is also remarkable for its considerable outcrop of greyish-green lherzolite—a bank 300 metres in depth—which rock Baretti[1] found to be composed of 75 per cent of olivine, and 25 per cent of greyish-yellow enstatite and green diopside.

As previously mentioned, the Ivrea diorite belt reaches north-east to the upper Sesia Valley above Varallo, where it becomes schistose and gives place to the so-called Sesia gneiss which, further east, in the Strona Valley north-west of Lake Orta, takes the name of Strona gneiss. Both gneisses are of the kinzigitic type already described, the Sesia variety being rich, the Strona variety poor in mica. The apparently abrupt cut-off of the diorite in Val Sesia was formerly regarded as evidence of a great hiatus due to a fracture fault; in reality, however, the diorite has its sequel between the Sermenza and Mastellone Valleys north and north-west of Varallo, where the

[1] M. Baretti, "Studi Gruppo Gran Paradiso": Mem. Acc. Lincei, Torino, 1876, p. 195 et seq.

kinzigitic gneiss is largely developed in its schistose form, associated with gneissiform, schistose diorite, norite, gabbro, and peridotite. The gneissic sedimentary rocks, known as stronalites,[1] are frequently intercalated in the eruptive series and vice versa. This high-level complex, reaching up to 2,500 metres altitude and including the schists of Fobello and Rimella, constitutes Gerlach's second, separate, upper dioritic zone; but, as Franchi and Novarese[2] have shown, it forms an integral part of the entire Lanzo–Ivrea–Verbano (Lake Maggiore) dioritic-kinzigitic area. A branch of the kinzigitic gneissic schist extends from the upper Sesia Valley west by Val Vagno and Croce Rossa into the upper Gressoney Valley, and thence connects with the eclogitic mica-schist of Val Pellina. In Val Sesia the mica-schist extends from Varallo down the valley, and is succeeded by the transverse granite belt, and then by the great porphyry mass of Borgosesia already mentioned.[3] It is a noteworthy feature that the Lanzo–Ivrea–Sesia zone descends to the very edge of the Po Plain, whereas along the western ridge of Lake Maggiore and beyond the kindred rocks are only found at high levels, the general direction of dip being thus north-east to south-west.

Stratigraphically the whole Ivrea – Val Sesia area within the Piémontese Alps presents the important phenomenon that all the eruptive masses are infolded in the mica-schist and gneiss formation conformably with the latter without any evidence of angular intrusion. This close association and relationship points to the entire crystalline, viz. both the sedimentary and the eruptive, series being of the same age, that is, Permo-Carboniferous. Lithologically, it is noteworthy that while the eruptive series includes every conceivable combination of felspar, quartz, and mica as primitive elements, the only rock conspicuous by its absence is diabase, probably because it associates more readily with the more highly magnesian calc-schist than with the mica-schist and gneiss formation.

It is, of course, quite impossible within the limits of this paper to describe in detail the outcrops in the numerous localities between the terminal points of Lanzo and Val Sesia. Suffice it therefore to state that from Lanzo to Ivrea and Biella the general vertical sequence is, in ascending order, mica-schists and eruptive rocks overlain by subordinate and isolated masses of indubitably Lower Trias crystalline limestone, while from Biella to Val Sesia the sequence is essentially one of juxta- instead of superposition. Of this superficial sequence the most typical example is the section, about 12 kilometres in length, along the Cervo Valley from Montesinaro to Andorno above Biella, which is shown in Fig. 4, and includes the whole eruptive series of old parallel lava streams infolded in the mica-schist

[1] The rocks of the Val Sesia and Val Strona region are described in detail in E. Artini and G. Melzi's "Ricerche petrogr. e geol. Val Sesia": Memorie R. Ist. Lomb., xviii, p. 219 et seq., Milano, 1900.

[2] Op. cit., 1905, 1906.

[3] There is apparently no passage from the granite to the porphyry or vice versa, but Franchi found (op. cit., 1906) a vein of porphyry in the granite mass, pointing to a somewhat later stage of eruption of the former within the same geological period.

formation. It was first pointed out by Gastaldi as early as 1871,[1] and cutting, as it does, right across the crystalline area, is still the most extensive and instructive, as it is also the most easily accessible section of the whole region.

IV. Conclusions.

The description given in this and the preceding papers of the six principal crystalline rock-areas of the Piémontese Alps, condensed and summarized though it necessarily is, will, I think, convey an adequate idea of the eminently characteristic geological and petrological features of each group. Though unique in their collective variety they reveal a certain uniformity of phenomena which from my own observations leads to the following conclusions:—

1. The pietre verdi, primitive and secondary, appear at all levels from the valley floors of 400 to the highest points 4,000 metres in altitude. Except the prevalence of pietre verdi with primitive elements in the minute gneiss and mica-schist, and of those with secondary elements in the calc-schist formation, there is no order of succession, superposition, or distribution.

2. The basic pietre verdi of all the areas, as well as the acid rocks of the Ivrea belt, are of eruptive origin, but not generally intrusive in the calc-schist and mica-schist formations. They appear in the latter not as irruptive, or as angular injections with apophyses, but as intercalated, lenticular, alternating, and concordantly stratiform planes and masses which sometimes produce the effect of pseudo-intrusive phenomena. There are frequent passages between the eruptive rocks, and from them to the sedimentary rocks and vice versa; but there is no reliable or conclusive evidence of contact metamorphism.

3. The close association of rocks of different origin is in the first instance the result of repeated compenetration of eruptive viscid masses and of sedimentary deposits in course of consolidation. After the resultant formation of conformable, alternating, interstratified planes as a submarine process of long duration, the rocks thus associated passed through the second phase of being raised and folded simultaneously during repeated earth-movements. The eruptive rocks of the Piémontese Alps are therefore of the same age as the infolding calc-schist and mica-schist formations respectively.

4. The process of pressure-heat- and hydro-metamorphism of both the sedimentary and eruptive rocks, already in progress before their emergence, continued not only during the repeated periods of raising and folding, but during the repeated Pliocene and Pleistocene glaciations under the long-continued, superincumbent, and shearing pressure of the ice, and the hydrating, decomposing action of percolating water, together with infiltrations from the Pliocene sea of the Po Valley. The dissolving action of the water thus imprisoned and circulating was intensified by the high temperature which it took from the rocks, in conjunction with thermal, highly magnesian springs at various depths.

[1] Gastaldi, "Studi geol. Alpi Occid.": Boll. R. Com. geol., 1871, p. 3 et seq., p. 17.

5. The formation of different groups and combinations of basic and acid rocks out of the submarine, viscid, heterogeneous magma slowly welling up from the reservoirs of molten material in the centres of eruption, took place according to chemical and mineralogical affinities, the basic material separating out, grouping, and crystallizing more rapidly, the acid more slowly. Hence the basic rocks of the Ivrea belt were probably consolidated at a somewhat earlier stage than the acid rocks, but within the same geological period.

6. The transformation of the pietre verdi with primitive to those with secondary elements is the combined result of metamorphism and of decomposition by hydration which led to the modification and re-formation of the decomposed elements to secondary groups and combinations. This process is much less in evidence in the pietre verdi of the older or mica-schist than in those of the younger or calc-schist formation, the mica-schist being much less permeable and magnesian than the calc-schist. The transformation probably took place in many cases during the initial stage of consolidation after the eruption of a highly magnesian magma in the calc-schist formation, e.g. in the areas of Monte Viso and the western part of the Lanzo valleys.

7. Chemical and mineralogical affinities produced in some cases basic rocks which, though frequently associated, preserved their separate entities, e.g. the associated but separate belts—originally parallel lava streams—of diorite and porphyrite (melaphyre) of the Ivrea area; or again, peridotite and gabbro and their derivatives serpentine and euphodite. The frequent veins and dykes of gabbric in peridotitic rocks show that the former compenetrated the latter when these, as the more basic, were already in course of submarine consolidation or alteration. Secondary amphibolites and prasinites are derived not only from diorite and diabase, but very largely, by metamorphism, from gabbro and euphodite which, in common with the other pietre verdi, also decompose readily to serpentinous schist or pseudo-serpentine. The gneissiform, calciferous, and schistose pietre verdi are the result, in some cases, of pressure-metamorphism, e.g. gneissic gabbro, gneissic diorite, etc.; in others of compenetration and metamorphism of sedimentary and eruptive material from tuffs and muds, e.g. diabasic and porphyric schists, or in relation to calciferous rocks, amphibolic and pyroxenic "calcefiri" and serpentinous "ophicalce".

8. The principal earth-movements experienced by the Piémontese Alps after their emergence came from the south-east, viz. from the Mediterranean and the Po Valley, as is shown by the precipitous and greatly folded flanks of the Maritime and Eastern Cottian and Grajan Alps which, together with the Lanzo–Ivrea–Val Sesia area, formed a coastal region contiguous to the Po Valley. Another, intermediate movement proceeded from the west and corrugated the great synclinal calc-schist formation. The principal fracture-faults of the Piémontese Alps are: (*a*) in the south, the transverse faults of the Stura di Cuneo and of the Col di Tenda and Vermenagna Valleys, along the north-western and eastern bases of the Argentera massif; (*b*) in the north, the transverse fault along

the Dora Baltea Valley; and (*c*) the great longitudinal subsidence zone south to north along the eastern margin of the Maira–Dora massif contiguous to the Po Valley. This subsidence or flexure zone, bordering on the Pliocene sea, probably extended along the base of the Lanzo–Ivrea–Val Sesia area and thence to the region of the lakes, thus constituting the zonal flexure or settling zone consequent upon the raising of the Alps in Eocene–Miocene times.[1]

Such is, in my view, the consecutive operation of causes and effects which produced the phenomenal masses and groups of eruptive rocks, their intimate association with the crystalline sedimentary formations, and the alignment and configuration of the Piémontese Alps of the present day. In their infinite variety they offer both geologically and petrologically an inexhaustible field of fruitful and fascinating study, and more especially does this apply to the pietre verdi, which Gastaldi rightly described as the great "magnesian zone", and whose elusive complexity ever reveals new problems without apparent finality.[2]

V.—On the Echinid Fauna of the Neogene Formations.

By R. Fourtau, Member of the Egyptian Institute.

I HAVE just finished the revision of the Neogene Echinids of Egypt preserved in the collections of the Cairo Geological Museum. Before the publication of this work, which will form the fourth fascicule of the *Catalogue of the Fossil Invertebrates of Egypt*, it has seemed to me that it might be useful to consider the fauna as a whole, drawing from it some conclusions as to the palæobiology of the Neogene seas of Egypt. I wish further to ascertain if the Echinids of this region can be of some aid as regards the stratigraphical divisions, and in synchronizing these with the divisions already established in the other regions of the Neogene basin of the Mediterranean.

The materials which I had before me for study were, in the main, collected by the late Mr. Barron in the Miocene region situated between Cairo and the Isthmus of Suez, and also in South-West Sinai. Those obtained by Dr. W. F. Hume in the Gebel Zeit area and by Dr. John Ball at Gebel Tanka, and in the neighbourhood of the mining region of Um Bogma (Sinai), have supplied valuable information, to which must be added interesting specimens collected by Mr. H. T. Ferrar at Mogara (Libyan Desert), by Mr. Hillman from the neighbourhood of Siwa Oasis, by Mr. J. Couyat-Barthoux in the Isthmus of Suez area, by A. E. Pachundaki and by myself in the neighbourhood of Mersa Matru on the Mediterranean coast of Egypt, 135 miles west of Alexandria. I have been able to identify

[1] *Vide* my previous paper, "The Moraine Walls and Lake Basins of Northern Italy," Geol. Mag., September, 1915, p. 409.

[2] The peculiar liability of the whole Italian peninsula to geological changes by eruptive and seismitic phenomena, past and present, was aptly emphasized by Professor A. Issel, of Genoa, the present President of the Geological Survey Department. Asked when the geological map of Italy, begun fifty years ago, would be finished, he replied: "like Penelope's web, *never*."

in these materials eighty-two definite forms (species, mutations, or varieties referable to twenty-three different genera).

The Holostomata are not numerous; *Cidaris avenionensis*, Desm., is represented by somewhat numerous radioles and some isolated plates; *Leiocidaris scillæ*, Wright, by tests and segments. The "gangue" of one of these tests contains some radioles which are very different from those attributed by Lambert to this form (J. Lambert, *Ech. mioc. Sardaigne*, p. 18, pl. i, figs. 11, 12). On the other hand, at a higher horizon than that of *L. scillæ*, radioles are present similar to those figured by Lambert, and which I have named *L. geneffensis*. The *L. sismondai*, Mayer, is represented by a unique specimen from the point of view of its preservation, an entire test in no way deformed by compression having been obtained by Dr. Hume in the Inner Zeit Valley, also by fragments of tests of some size and fairly numerous radioles.

The Glyphostomata belong for the most part to the Echininæ. The *Psammechinus* are numerous, eight different forms, some of which give evidence of indisputable passages to the sub-genera *Anapesus*, Holmes, and *Schizechinus*, Pomel; thus showing the little value to be attached to these determinations, of which the utility never seemed clearly demonstrated. In close relations to the *Psammechinus* are a number of small sea-urchins, to which certain authors, who ascribe an exaggerated importance to the very difficult study of the pedicellariæ, which themselves are not found in the fossil state, have wished to place in the Temnopleuridæ, although they have neither true or false pits nor low sutural impressions, and their plates are not united by dowelling. These sea-urchins, attributed formerly to the genus *Arbacina*, Pomel, of which the type *A. monilis*, Desm., has sutural impressions which are sometimes very difficult to observe, have lately been separated from it by Lambert et Thierry and been placed in the genus *Prionechinus*, Al. Agassiz. Unfortunately, this genus *Prionechinus* has been wrongly defined and, moreover, imperfectly figured by its author, so that one is led to inquire if the fossil forms quite agree with the characters contemplated by Agassiz when he established this genus. Consequently I am of opinion that a new determination is necessary, and have proposed for this Echinid the name *Pseudoarbacina*.

I have also pointed out that among the *Temnechinus* of the Gaj Series of India, the *T. stellulatus*, Duncan & Sladen, may be separated from this genus because it does not possess the false pits or low sutural depressions which characterize *Temnechinus*, Forbes, *Opechinus*, Desor, and true *Arbacina*, Pomel. As *T. stellulatus* presents a peculiar ornamentation, having its secondary tubercles united with the primary ones by radiating miliaries, it must be considered as the type of a new genus of the Triplechininæ, for which I propose the name *Brochopleurus*. A form allied to *B. stellulatus* has been found by A. E. Pachundaki in the Miocene range of the Marmarica near Mersa Matru, and described in 1907 by Lambert under the name *Opechinus fourtaui*.

The Temnopleuridæ are only represented in Egypt by a new form belonging to the genus *Lepidopleurus*, Duncan & Sladen.

The Gnathostomata are represented by forms belonging to the genera *Echinocyamus*, auct. (*non* Lambert), *Scutella*, Agassiz, *Amphiope*, Desor, and *Clypeaster*, Lamarck. Two forms, one Miocene, *E. stellulatus*, Capeder, the other Pliocene, *E. pusillus*, Müller, represent the first genus. The *Scutellæ* are represented by six forms all peculiar to Egypt, the *Amphiope* by three species, of which one, *A. palpebrata*, Pomel, is characteristic of the Burdigalian of Portugal and Algeria. Finally, the genus *Clypeaster* is represented by one Pliocene species and by eighteen from the Miocene. It is interesting to note that all the Miocene forms in Egypt are low or of very small elevation, and nowhere in this stage have those grand types of notable dimensions been met with so frequent in the Neogene of the Western Mediterranean, not only in Algeria, but also in Spain, France, Corsica, Sardinia, in Upper Italy, and more rarely in Malta. The presence in Egypt of depressed forms such as *C. intermedius*, Desmoulins, *C. marginatus*, Lamarck, and *C. martini*, Desm., or of moderately high ones such as *C. crassus*, Agassiz, *C. scillæ*, Desm., and *C. subdecagonus*, Peron & Gauthier, forms which are found in the western regions, forbids the hypothesis of difficulty or discontinuity of communication between the oriental and occidental basins of the Miocene Mediterranean, and the more so that with the Pliocene there appears in Egypt a representative of the group of *C. altus*, Klein, the *C. ægyptiacus*, Wright, which is so polymorphic that certain of its specimens display the typical aspect of the ancestral form and of its variety, the *C. portentosus*, Michelin. We are therefore led to think that this absence of forms, with thick and very high tests in the Egyptian Miocene, is due to the composition of the waters and the littoral deposits of this sea, which did not contain sufficient carbonate of lime of the calcite type so assimilable as to permit the *Clypeaster* developing the plates of their test in sufficient thickness and the pillars of their endoskeleton destined to support the inflation of their ambulacral rosette.

The Atelostomata are as abundantly represented as the Gnathostomata, and by a larger number of genera.

The *Pliolampas*, Pomel, are represented by three forms, of which one, *P. welschi*, Pomel, is known in Algeria. *Echinolampas*, Gray, has twelve species, of which three, *E. plagiosomus*, Agassiz, *E. montesinensis*, Mazzetti, and *E. pignatarii*, Airaghi, belong to the Conoclypeiform group; the others are all true *Echinolampas* with test of small elevation. One only, *E. hoffmanni*, Desor, is Pliocene.

The genus *Pericosmus*, Agassiz, is only represented by the typical species, *P. latus*, Agassiz, which is very abundant at several levels. The genus *Brissopsis*, Agassiz, is also only represented by a particular race of *B. crescenticus*, Wright, *B. fraasi*, Fuchs. There is only one representative of *Agassizia*, *A. zitteli*, Fuchs. The genus *Opisaster*, Pomel, is represented by two forms which appear to be successive mutations of the same type, *O. lovisatoi*, Cotteau, and *O. almerai*, Lambert. The specimens of *Schizaster*, Agassiz, are in general so badly preserved that it is only possible to mention two species with certainty, *S. eurynotus*, Agassiz, and *S. legraini*, Gauthier. The genus *Trachyspatangus*, Pomel, is represented by *T. tuberculatus*,

Wright, which is also found at Malta, in Corsica, and in Sardinia. The existence of *Spatangus corsicus*, Desor, in Egypt, is not definitely established, but *S. pustulosus*, Wright, can be mentioned without hesitation.

Maretia (*sensu lato*), Gray, is represented by two forms peculiar to Egypt, *M. fuchsi*, Oppenheim, which appears to be a simple mutation of *M. tuberosa*, Fraas, which, in its turn, might in reality only be a variety or race of *M. ocellata*, Defrance. I have not thought it necessary to maintain the genus *Hemipatagus*, Desor, the primary tubercles of the Egyptian forms have deeper "scrobiculæ" than those of the present-day *Maretia*. These "scrobiculæ" in reality only produce swellings in the interior of the test and not the "ampullæ" so characteristic of the genus *Lovenia*, Desor. If the *M. ocellata* from the Miocene of the neighbourhood of Bordeaux have, as says Lambert, scrobicular "ampullæ" in the interior of the test, the question will arise whether they should be separated from the genus *Maretia*, and also if they agree with Defrance's type, which came from the Rhone basin, and with the Swiss neotype, the only one figured to this day by Agassiz and de Loriol, who never made any reference to the presence of these "ampullæ" in the specimens they studied.

Two Miocene forms of *Lovenia* are new and peculiar to Egypt. Finally, the genus *Echinocardium*, Gray, is represented by three species; two of these are Miocene, of which one is *E. depressum*, Agassiz, and the third is of Pliocene age.

As regards geographical distribution, we have been able to note 35 forms common to Egypt and the western basin of the Mediterranean, including 9 Miocene *Clypeaster*. Of these forms 12 are present in Algeria, 21 are found in the Miocene of Italy and the Italian islands of the Tyrrhenian Sea, 8 exist in Malta, and 14 in the Neogene of the Rhone basin in France, and up to the present 40 appear to be special to Egypt.

It is interesting to lay special stress on the presence in Egypt of a representative of the genus *Lepidopleurus*, which till now has been exclusively Indian, and of a form very near *Brochopleurus stellulatus*, Duncan & Sladen, also from India.

From the palæobiological point of view (leaving aside the Pliocene Echinids, which have only been found in Egypt in a single locality near the pyramids of Giza) a quasi-independence can be noted between the two Egyptian Miocene basins to the east and west of the Nile Valley respectively, which only have five forms in common and three species, represented by varieties in each basin. Of species with Indian affinities, one is in the eastern basin and the other in the western. It should be noted that the Lower Miocene is represented in these two basins by two forms common to both: *Scutella zitteli*, Beyrich, and *Schizaster legraini*, Gauthier.

We may explain this dissimilarity of fauna by the difference of the facies in the two basins. In fact, the Middle Miocene deposits of the western basin are nearly exclusively formed by a mass of very ferruginous and siliceous hard limestones, interbedded with more or less sandy layers and overlying a detrital formation of ferruginous

sandstones. Only flat Clypeasters are found in these beds. In the northern part of the eastern basin, between Cairo and Suez, the *Lithothamnium* and foraminiferal beds alternate with soft sandy limestones and coral reefs. Their fauna is richer and the Clypeasters are higher, whilst the southern part of the same basin possesses a very sparse fauna, this being due, in spite of the abundance of limestones, to the influence of the phenomena which have given rise to the oilfields.

On the other hand, the Lower Miocene deposits are detrital or of purely littoral origin in the western basin, whilst in the eastern basin their facies indicates neritic and bathyal formations except at the eastern foot of the Geneifa range, where they are littoral as in the western basin.

Now, the abundance of *Scutellæ*, which in places form a very shell-breccia, indicates a general facies of littoral or sub-littoral characters, this being confirmed by the relative rarity of the Cidaridæ and also of *Brissopsis*, an essentially deep-sea genus.

Stages.	Horizons.	Characteristic Echinids.	
Upper Neogene.	Plaisancian–Astian.	*Clypeaster ægyptiacus*, Wright. *Echinolampas hoffmanni*, Desor.	
		Western Basin.	Eastern Basin.
Middle Neogene.	Vindobonian.	*Amphiope fuchsi*, Fourtau, *Scutella hunteri*, Fourtau, *Clypeaster martini*, var. *rohlfsi*, Fuchs, *Echinolampas amplus*, Fuchs, *E. plagiosomus*, Agassiz, *E. hemisphæricus*, Lamarck.	*Leiocidaris sismondai*, Mayer, *Clypeaster isthmicus*, Fuchs, *Scutella deflersi*, Gauthier, *Pliolampas pioti*, Gauthier, *Echinolampas amplus*, var. *meridionalis*, Fourtau.
Lower Neogene.	Burdigalian.[1]	*Scutella zitteli*, Beyrich.	*Scutella zitteli*, Beyrich, *Clypeaster depereti*, Gauthier, *Echinolampas orlebari*, Gauthier, *Brissopsis crescenticus*, race *fraasi*, Fuchs, *Maretia tuberosa*, Fraas.

From the point of view of stratigraphical divisions and their synchronization with the horizons noted in the different regions of

[1] The recent discovery of the *Echinolampas discus*, Desor, by Lieut.-Colonel W. E. Jennings-Bramly, at Gebel Hamamia near Birket Mogara, in the Western Desert, seems to indicate the presence in Egypt of marine deposits belonging to the lowest horizon of the Neogene, the Aquitanian.

the Neogene Mediterranean basin, we find ourselves in the presence of great difficulties, arising from the extreme variation in the character of the fauna and of the lithological composition of the littoral deposits. We have, therefore, to content ourselves by adopting in very broad lines the divisions of Lower, Middle, and Upper Neogene, corresponding to the three Mediterranean stages of Suess, or accepting the terms Burdigalian, Vindobonian, and Plaisancian of French authors, attention, however, being called to the fact that the last term includes the Plaisancian and Astian of the older authors. This being established, we can give the following species as characteristic fossils of each of these divisions in Egypt.

I am indebted to Dr. W. F. Hume, F.G.S., Director of the Geological Survey of Egypt, for kindly translating this paper into English.

VI.—The Upper Trias of Leicestershire.

By A. R. Horwood.[1]

(*Continued from May, 1913, p. 215.*)

(WITH A MAP AND PLATES.)

Part II (*continued*).

4. Physiography.
5. Tectonics and River Development.
6. Petrography and Lithology.
7. Palæontology.
8. Economics and Water Supply.
9. Sections and Correlations.
10. Bibliography.
11. Appendix.

4. Physiography.

A STUDY of the local stratigraphy, tectonics, petrography, and palæontology leads to some conclusions as to the physiography of the epoch in this district. Even studied as a detached area it may be noticed that the Bunter or pebble deposits are west of the sandstones and marls. From the fact that the eastern limits of the first two are west of the marls, and the second (sandstones) west of the pebbles, and from the evidence of other areas, it appears that this purely local west to east succession is applicable to the whole British area, and it is well known that each member thins from north-west to south-east (as a whole). This is the sequence typical of aqueous deposits, and particularly of delta deposits, and at the same time indicates (in part) the direction from which the sediment came.

Remarks have already been made as to the eastern limits of the Bunter and the Lower Keuper. Borings under later Mesozoic and Neozoic rocks (chiefly in search of coal)[2] show that the limit of the Red Marl is decidedly further east than that of the Bunter or Lower

[1] Aided by a grant from the Government Grant Committee of the Royal Society.

[2] See Harrison, Ussher, McKenny Hughes, and Royal Coal Commission Reports, etc.

Keuper. It is clear that these facts are intimately interwoven with the three prime movements, Caledonian, Charnian, and Pennine, affecting this area, with the noticeable overlap, erosion of pre-Triassic land-surfaces, as well as the causes already mentioned, of the normal deltaic succession.

The sandstone horizons intercalated between the marls, in both Lower and Upper Keuper, when not lenticular, suggest shore conditions, a fact proved by the character of the flora and fauna as well. Usually they retain traces of delta-bedding, which must be taken to mark fluviatile or estuarine conditions. It is possible that some of the lenticular bands may be due to the alternation of seasons of overflow or flood and drier conditions, and represent the sand or silt caught upon normally submerged banks of muddier sediment. The explanation that these white or grey sandy calcareous zones owe their colour to bleaching, or exposure to atmosphere (and they alone contain ripples and salt pseudomorphs), is corroborative of this suggestion. As they occur in the Upper Keuper in the red beds in what I regard as the lake phase of the delta epoch they would hardly be sediment deposited on river banks as in the Mississippi, but rather accretions to submerged mud-banks, and the difference in the character of the sediment[1] would be due to abnormal sequence of deposition at flood-times, i.e. thin beds of silt or sand in place of mud over deposits in deeper water, instead of in thick beds near the shore.[2] The alternating sandstones and marls in the Lower Keuper may be in part due to overflow of banks, in part to deposition nearer shore, before the lake phase commenced.

The height to which Red Marl reaches at Bardon Hill is somewhat difficult to explain except upon the supposition that there was considerable oscillation of level, and as in a river valley deposits may be formed at different levels so that the sequence may be obscured, so the isolated marls at Bardon may be regarded as homologous with beds at different levels elsewhere. The existence of Rhætic and Lias outliers west of Charnwood at Needwood Forest and elsewhere indicates that originally Charnwood was not, as now, a lofty peak, but buried in deposits now cleared away by denudation between Jurassic and Glacial times. The relative position of the Bardon Marls, however, in the sequence affords a datum-line upon which to estimate the thickness and extent of strata removed.

The stratigraphic details given show that, as Dr. Matley finds in the Warwickshire area, there is, apart from the south-easterly dip and the radial dip around Charnwood and similar ranges of hills, a marked uniformity in the horizontal character of the beds. This must be discounted in so far as the occurrence of flexures can be indicated in this area by gentle undulations connected with the main movements affecting the Midlands.

A feature to be remarked upon, further, as to the relation of sandstones and marls is the preponderance of the latter in regard to vertical height and horizontal extent. The proportion of sandstone

[1] Grey beds more arenaceous and calcareous, of higher specific gravity than the red beds.

[2] Carried further out by the increased velocity of the current.

is greater in the Lower Keuper than in the Red Marls. On the whole there is, where the sandstones are fully developed, one-third sandstone to two-thirds marl. In the Red Marl the proportion, even including skerries and thin sandy beds, is hardly more than one-twelfth. This relative proportion of marls to sandstones is, taken in conjunction with their place in the full sequence, following pebble beds, the natural succession in aqueous deposits, especially those originated by a river and forming in due course a delta.

Not less clear, as seen by a study of the petrography, is the fact that, commencing with the Bunter, the deposits graduate upwards into finer and finer sediments right up to the Rhætics. It is true that there are interbedded coarser sands in the marls high up, but these are explained as abnormal in the lake phase, and they are as a whole most predominant between the pebble beds and the lower part of the Upper Red Marls, their proper position in a delta succession.

In the Coal-measures laid down under delta conditions, there are rock courses or ancient river-beds in the lower part of the Middle Coal-measures. They do not appear higher up, and it is clear that the highest red beds, like the Red Marls, represented the lake phase. In the Trias we should not expect to find traces of the river-bed higher than the Lower Keuper, and though there is no strict analogy to be pointed out, yet in Bunter and Lower Keuper delta bedding and wedge-bedding and similar obscure types of deposition indicate that a river-bed might be sought if sections existed under Liverpool or in that direction, assuming one river came from the north-west.

The direction from which the sediments came may be to some extent proved by the occurrence of extraneous material for which a definite source can be adduced. Thus the occurrence of galena in Carboniferous Limestone nodules in the Lower Keuper at Shepshed, which is found in situ at Dimmingsdale to the north-west, furnishes one indication. Coal has been found also in the Upper Keuper Sandstone at Leicester, and it is reasonable to assume that this also was derived from the north-west, or the Ashby Coalfield.

The constant occurrence of current or delta bedding, noted in many instances in describing the stratigraphy, both in the Lower Keuper Sandstones and the Upper Keuper Sandstones, shows that, on the whole, they follow the direction of dip to the south-east (from north-west). When beds are uniformly bedded in this way it is usually held that, as in the Coal-measures, river agency produced the oblique laminations. This, again, points to the direction of the river and source of sediment.

Again, the evidence of ripples shows that the period was marked by constant shallow-water conditions, and the presence of land in the vicinity, with intervals of depression between. The ripples trend largely north-west and south-east in the Red Marl, varying mostly in the Lower Keuper, to the opposite direction, and in the latter the dip is also more variable. I consider the crest of the ripple was parallel to the direction of the flow, and do not think they were produced by a river at right angles from the south-west, but were formed by lateral ebb and flow. It has been suggested that in the variegated

beds the grey bands are bleached out by drainage along the lines of more porous beds, since they were covered up. But this cannot be so, because they differ in chemical composition and specific gravity from the Red Marls, and they alone contain ripple-markings. As to the absence of ripples in the red beds, this is natural because they are thicker, laid down in water originally deeper where ripples could not be made, while in the shallow sandy grey beds (nearer land or superposed in flood-time on submerged mud-banks) they are general.

An analogy for the grey beds overlying red beds is found in the Magdalen Islands, in the Gulf of St. Lawrence, where there are purple sandstones with a persistent covering of white sands, decoloured by organic acids. A recurrence of this each time would explain the repetition of variegated beds.

Suncracks occur commonly on the surfaces of the Lower Keuper marly beds, and in a few cases in the flaggy beds in the Upper Keuper Sandstones, testifying to the periodicity of terrestrial surfaces and the proximity of land. The association of footprints with them proves that the phase was of some duration. Rainprints occur with the suncracks, especially in the Lower Keuper in North and South Leicestershire, indicating that (as they are numerous and abundant) the climate was not particularly arid, since large amphibious creatures lived along with plants such as Equisetaceæ which required excessive moisture. A somewhat modified type of climate existed similar to that met with in the Coal-measures suitable for the formation of thin carbonaceous layers (incipient coal-seams), and if the occurrence of bitumen can be attributed to a similar origin (unless it is volcanic, for that also may be suggested), though it was undoubtedly drier and less humid, and the sun-rays were not obscured, as it has been doubtfully suggested they were in the Coal-measure period.

The widespread occurrence of pseudomorphs of salt crystals in Lower and Upper Keuper suggests that shallow water lay for periods upon flats that were allowed to evaporate before they were submerged again. The preponderance of brine thus indicated, as well as by the occurrence of brine in Triassic waters, bears out the old view of the saline character of the waters, and justifies the old name "Saliferous Red Marls". That salt occurs in abundance in dry regions with similar pseudomorphs is well known. We need, however, to take into account the innumerable other indications that the period was one in which water was the prime agent of importance.

Besides the continuous thick gypsum bed, not far below the Tea-green Marls, there are a number of other horizons at which it occurs in the Red Marl, as shown by the Crown Hill and other borings. It is also found in the Lower Keuper, but here as in the Orton Sandstone Group the bands are thinner. As a rule they are continuous, and a marked feature is their horizontality. This and the thickness of the band near the top make it clear that the gypsum was deposited in shallow lagoons liable to be inundated. Its frequent association with Green Marl and Skerry suggests it was formed at seasons of flood followed by drier periods allowing desiccation. It is probable that the reticulated bands and some ball gypsum are of secondary origin, formed by infiltration from above. The nodules at

the Star Brick Pit show a stage in which carbonate of lime was more plentiful than sulphate of lime. The occurrence of brine (see Water Supply) in some abundance in Triassic waters, evidenced also by the salt crystals, shows, as does the presence of lime combined as sulphate and carbonate and as pure lime, that marine conditions were not far removed from the lacustrine phase, or else that from the land side a different source was being tapped totally unlike the highly aluminous Red Marl or lacustrine phase. That Rhætic beds were being laid down further east during the Red Marl period here would account for such marine incursions. If water with brine and coarse sediments were swept westward temporarily they would naturally give a different result under abnormal conditions from the deposits in the typical Rhætic sea.

The occurrence of beds of bitumen in the Lower Keuper Sandstone is an indication that either carbonaceous deposits were laid down as in the Coal-measures, or else that it was poured out by volcanic agency as a subsidiary lava-flow. But it is not usually held that coal is bituminous in this sense, so that the second view must be held. It has even been suggested that gypsum may have owed its origin to a similar agency, volcanic activity, the water causing the sulphur emitted to be precipitated as a sulphate of lime. Volcanic activity is known in the Permian to have been extensive, but to what extent, if any, in Keuper times is uncertain.

The coloration of the rocks at present is a matter of difficulty. If the green colour was original or the red colour conveyed in chalybeate waters,[1] the investment of each grain must have been by a movement from below upwards to explain intervening green bands, unless these were bleached as each grey horizon was at the surface, as may be suggested, and it may then be said that the red intervals indicate the amount of submergence after each such bleaching.[2] Intimately connected with it is the difference of physical characteristics, composition, and specific gravity of the red and green bands (see Petrology). Variegation was due to two processes. Firstly, the grey bands were decoloured after being coloured red by organic acids at the surface, being formed in shallow water over mud-banks and exposed to the air, where worms, possibly bacteria, etc., may also have played a part. This denotes oscillatory movements. Secondly, the sandstones heavier and containing more calcareous matter may have been laid down at flood seasons as the grey bands probably were, but in this they were perhaps never submerged again after they were raised along the higher levels of the river-head. Being derived from a different source they differ in constituents from the marls.

The desert conditions described in connexion with Mountsorrel Croft, etc., all relate to granitic or syenitic rocks. Frost and heat, alternating with cold, help to disintegrate granite, and it is liable to split up into blocks. The sand thus formed accumulates as a talus. Even a slight wind will set up sand-blast action, causing polished surfaces. As we examine the eastern boundary of the

[1] Accepting Dr. Moody's view.
[2] Following deposition of red colour.

Trias not far from the delta-head, it would be natural to find at this point a considerable extent of blown sand and dunes at the bar of the delta. But the evidence is confined, in the Soar Valley, more or less to a level of 300 feet O.D.

The sort of conditions prevailing then, locally, show that in Lower Keuper times the sediment which was detrital, laid down under estuarine conditions, thickened westward, and the waterstones and marls became transitional to the next phase (lacustrine). In the Red Marl phase calcareous strata thickened eastward, arenaceous westward, as in the Coal-measures according to a general law, but on the whole the sediments thin to the south-east, and were laid down under lake conditions, the river being gradually absorbed. Some agency contributed to the unsuitable state of the waters for organic life (sulphurous?), but at rare intervals some submerged land arose and animal and plant life were able to subsist for a time. Probably in this way the flora and fauna were markedly migratory.

During the Rhætic phase in England (earlier on the Continent) initial marine conditions arose, and the Keuper waters gradually lost their distasteful character, though the stunted fauna at this time shows that there was a struggle for existence. The Triassic flora and fauna, as a whole, do not bear any resemblance to those of dry regions to-day, but rather resemble in composition those of the estuaries, swamps, and lagoons in and around the mouths of large rivers and their banks, which, again, have a direct communication with the sea.

The Upper Carboniferous was a period during which the surface was depressed, with periodic elevations. During the Permian there was depression for lacustrine and marine conditions, and elevation for the manifestation of volcanic activity. The Trias at its commencement was an elevated area, and there was a gradual submergence or subsidence up to Rhætic times with intervening oscillations and periodic elevation. The conditions may be summed up in tabular form thus:—

Phase.	Agency.	Type of Physical Conditions.	Derivation of Sediment.
Bunter.	River.	Torrential or pluvial fluviatile.	N.W. Scotland, in Midlands, Lickey's Hartshill, etc. (quartzites, etc.).
Lower Keuper.	River.	Formation of head of delta and lagoons (estuarine).	Millstone Grit, Coal-measures, Permian.
Upper Keuper.	River, merging into lake, with overflow of silt.	Lacustrine (waters sulphurous).	Granites and syenites of Midlands, Coal-measures, Sandstones, etc.
Tea-green Marl.	,, ,,	Estuarine and lacustrine initially marine.	Ditto.
Rhætic.	Transition from lake to sea.	Initial marine phase.	Ditto, Coal-measures, shales for detrital matter, carbonate of lime from organisms.

5. Tectonics and River Development.

Any consideration of tectonic structure must be, to some extent, affected by the evidence of denudation preceding and following the formation, of which the structure is discussed.

There is considerable local evidence of pre-Triassic denudation in post-Carboniferous and pre-Permian times. This is shown by the absence of higher beds in the Ashby district. It is shown also by the occurrence of hæmatite nodules in Permian beds containing plants derived from the Coal-measures. There is evidence in the Permian that locally the deposits are non-sequential, due either to land-oscillation or denudation. The Lower Keuper, as has been intimated, is locally deposited on the eroded surface of the Bunter, a feature noticed also in the Newark district. The character of the Triassic sediments indicates that the Palæozoic rocks were greatly worn down to furnish the source of their material.

The evidence of the Drift deposits shows that much of the Trias has been denuded by glacial agency, the extent of which cannot be estimated. Furthermore, the probable formation of an earlier peneplain between Liassic and recent times and a later one giving rise to present drainage systems must account for much modification in the configuration of Central England. The loss of the Keuper between Mesozoic and Pleistocene times was probably considerable, evidence of which is afforded by marls low down at 880 feet at Bardon, and the existence of outliers of Rhætic beds at Needwood Forest, west of the Charnian range.

The general structure of the Upper Trias may be summed up as follows: The Lower Keuper is characterized by the sloping nature of the scarps formed by the sandstone features. A series of stone beds near the top forms a small escarpment below the Orton Sandstone Series, as in the east of the Mease Valley and south of the River Trent. The marly beds form flat country as in the Mease Valley, and less so north and south of the Trent.

The lower part of the Red Marls present gentle slopes up to the escarpments of the sandstones of the Orton Group in the Mease Valley, and between Castle Donington and Kegworth, exhibiting sinuous flexures. The sandstones form ridges, a modified plateau on plateau structure along the top of the escarpment, and where they broaden out and are exposed at the surface they afford flat tablelands. The marls below exhibit gentle dip slopes.

The Upper Keuper Sandstones, Dane Hill Series, occur as high ground with a steeper, less marked dip slope, and as the sandstone beds are more massive, but local, the hills present only small plateaux.

In Notts the Red Marl is characterized by steep slopes with sharply defined upper margins bordering the flat plateaux, which descend gradually to the south-east, representing the dip slope of the marls. Here, though the position of certain skerries can be ascertained, their extent as in Leicestershire cannot be followed, and in this district the Drift obscures wide tracts. The skerries give rise to flat plateaux, and on the gentle dip slopes form sandy belts. This character is noticeable also in Leicestershire. In the Melton district, in the absence of features formed by skerries,

the country is gently undulating with occasional conspicuous hills, crowned by patches of sandy drift. Over a great part of Leicestershire this feature is well-marked.

There is no doubt that the alternation of hard skerries or sandstones and soft marls causes to a great extent (along with drift mantles) this type of country with ridge and furrow on a large scale. The occurrence of these undulations are evident from Gloucestershire as far as Newark.

The same sort of differentiation may be attributed to the Lower Keuper, and the position of stone beds at the top of the waterstones about Appleby up to Normanton, as in the Notts district noticed by William Smith, is of a similar order. The same features occur around Kegworth. Flat-topped hills are formed by the sandstones in the Notts district.

In general the dip is south-east as a whole, but varies from point to point in direction and degree, a fact which must be put down to the existence of undulations that can only be indicated provisionally. Another cause for variation in this is the necessarily radial or quaquaversal dip around Charnwood Forest, and submerged granitic and syenitic knolls. Away from these last, where it exceeds the average amount of 1° to the south-east and differs in direction (as noted earlier in this paper under stratigraphic details, and *vide* Map), it may be concluded that there are a series of synclines and anticlines with dome structure, as observed in Gloucestershire by Mr. Richardson and in Warwickshire by Dr. Matley. As remarked, the Lower Keuper exhibits in Leicestershire most variation, because its outcrop is less obscured by drift than the Red Marl, where few dip calculations can be made (except radial dip around Charnwood, etc.). And it has been noted already that in places the waterstones thicken locally to the west. In Notts they thicken westward at Burton Joyce, Thurgarton, and Newark, due to an actual thickening or to a persistence of sandy beds higher up in the Marl Series, or to both causes, as noted by Mr. Lamplugh.

It is plain that the earth-movements preceding the Triassic period have affected the later rocks, and that folds then produced have influenced beds of later age, the folds being accentuated by subsequent movements. The Pennine Chain, which was initiated after the Coal-measure period and before the Permian, is one of these, running north and south. It is probable that it has acted upon the later Triassic rocks in the Kegworth district.

Disturbances in the Lias near Barrow show the influence of movements north-east and south-west, or Caledonian in character. Faults such as the Sileby and Barrow fault are of Charnian type, north-west and south-east in trend. All these three movements have not only influenced rocks earlier or later than the Trias, but these earlier faults have also been affected by the later ones.

The strike is mainly north-east and south-west, as in other areas, and Caledonian in direction. The faults at Glen Parva and Spinney Hills, north-west by south-east, are of Charnian character, a direction initiated in pre-Cambrian times, and doubtless this movement has been continuous since. The dome structures of Langcliffe and Enderby

are of the same type, and have modified the stratification in each case. Some old gullies as at Bardon, also Charnian in direction, are filled with Trias.

The flexures of the Orton Sandstone group suggest that undulations in that direction are due to those of Charnian type. Those at Kegworth may be Caledonian and Pennine, whilst the folds that affect the Upper Keuper Sandstone Dane Hill group are also Caledonian.

Faults are uncommon. A few occur in the Burton district in the Red Marl. The Lower Keuper is faulted in the Ashby district and at Castle Donington. The Rhætics exhibit faults at Glen Parva, East Leake, Spinney Hills, Barkby Thorpe, and at Barrow, chiefly of Charnian direction, or Caledonian. W. Molyneux was the first to suggest the occurrence of flexures in the Red Marl in this district. But he used the term in a different sense. Describing a section at Horninglow, just outside this area, near Burton, and at Tatenhill, he remarked upon the irregular lines of red and blue marl, as having a curved or wave-like appearance. He attributed it there to the unequal distribution of colouring matter in the marls. While the upper sandstone beds are horizontal the lower exhibit curvature, "contortions," or "flexures". They are undoubtedly instances of undulations which would give rise to flexures at the outcrop.

Jukes noticed how in the Charnwood district "the stratification of the red marl conforms to the uneven surface of the slates, rising up on the slope of its peaks and sinking gently in its hollows, showing its deposition to have been very gradual and tranquil, and also that the slate rocks had been both upheaved and worn into peaks and hollows before the deposition of the red marl". Writing of the sandstone horizon at White Horse Wood, he says it is "no doubt the original position in which it was deposited, and not due to its subsequent elevation"; and as to the relation of marls and sandstones to the older rocks, the two remarkable circumstances are "their horizontality, compared with the highly inclined position of the beds on which they rest. The second is the height at which they are found, being considerably above that to which the beds of the formation generally attain in the surrounding country".

In reference to the denudation of the Trias he says, "The original surface of the New Red Sandstone was probably a nearly perfect plane, rising gently on every side towards the Forest, filling its valleys and mantling round its sides, leaving none but the higher peaks exposed to view. Over this nearly horizontal plane lay the Lias, equally, if not more, horizontal, thinning out and ending probably towards the Forest,[1] but approaching it much more nearly than it does now. To produce the existing undulating surface, all the Lias west of its present irregular and broken boundary, and much of the New Red Sandstone beneath, has been removed by currents of water, [drift] scooping and hollowing it out, and producing the present valley of the Soar and its collateral valleys. Portions of the higher beds of New Red Sandstone, namely the variegated marls, protected by the solid rocks around them, have been left in the Forest to show the

[1] At that time the Needwood outlier was not known.

height the formation once attained,[1] and to mark the destruction caused by the denuding forces."

There is no doubt that the influence of the buried landscape of Charnwood Forest has modified the normal bedding of the Red Marl in its immediate vicinity, and the footnote Jukes adds shows that he attributed the radial dip to the true cause, the natural angle of rest of particles deposited on inclined slopes. In exhibiting a resemblance to quaquaversal dip in relation to the surrounding synclines, which meet the deposits showing radial dip, it may be that in some cases the dip is not always radial in relation to the older rocks, but due to undulations caused otherwise, or as at Enderby and Longcliffe, for instance, to the anticlines of the Charnian range itself.

The height of the Trias at Bardon where skerry bands lie high up in the big quarry, whilst capable of more than one interpretation as already remarked, may very probably represent the flexure of a portion of a dome structure of which Bardon is the axis, but the beds cannot certainly be correlated with their continuation at lower levels under the Red Marl, and are only exhibited on one side of the hill. If this interpretation is correct, it does not affect the equal probability that the Red Marl rose on all sides to heights approximating to that reached at Bardon.

Mr. Harrison, in describing the relation of the Red Marl to the syenite of Enderby, says "everywhere they follow the irregular surface of the syenite, in one place filling up a deep hollow in that rock, so as to be perceptibly curved". And as to Croft, he remarks, "Here again we see the Keuper red marls and sandstones resting upon the syenite, from which they slope rapidly away in all directions." It is interesting to note that then, in 1884, Mr. Harrison, in writing of the polished surface of the syenite overlaid by sand and "boulders", remarked that they "may have been due to the friction of the sand". Thus, while describing this as an ancient sea-cliff (at 320 O.D. like the other horizons) he was the *first* to suggest æolian agency for this phenomenon locally, as Professor Watts did not describe the wind-polishing at Mount Sorrel till 1889. The explanation of curvatures at Enderby and Croft may be attributed to radial dip influenced by dome structure in the first case, and at Croft initially to radial dip between, more than one submerged peak giving rise to catenary bedding, though it is probable that they are of the same character as the undulations elsewhere.

A. H. Atkins, in noticing "glacial markings" in the Red Marl at Small Heath, near Birmingham, remarked upon the contorted nature of the white bands and of the twisted and broken beds of clay above, and at Adderley Park upon puckerings in grey bands about 6 inches high, like those in Red Marl at Sileby, perhaps. These phenomena were most likely also due to undulations. Hull in 1860 remarked upon the probable influence of an anticlinal in producing the inlier of

[1] "It is not meant that even the highest beds of the New Red Sandstone ever attained the same general height over the surrounding country which they have in the Forest, as they would naturally be deposited on a gentle slope, rising higher on the sides of the hills than elsewhere."

sandstone at Diseworth, coupled with denudation. He also suggested the occurrence of a syncline at Smisby of Red Marl.

Under stratigraphy and *ante* (under Tectonics) I have alluded to the evidence of flexures in the Orton Sandstone group and the Dane Hill group, whereby loop-like outcrops are produced owing to the influence of undulations in the beds themselves. Several circumstances combine to render the data for their delineation on the map fragmentary, apart from the general obscuring effect of the drift. The Orton-on-the-Hill series is developed along the outcrop, but this is buried to the east under drift and the influence of dip, and cut off to the west by the River Mease, and to the north by denudation of the Coal-measures and higher beds (post-Triassic). Around Kegworth it is buried by drift and cut off by the Rivers Trent and Soar.

The Dane Hill series is actually persistent, but occurs in isolated patches due to (1) Soar Valley excavation, glacial and recent (as well as pre-glacial); (2) covering of drift, and pre-glacial denudation elsewhere. They have been well described by L. Richardson in the Eldersfield district, and by Dr. Matley in Warwickshire. In Notts they have been noticed at Lambley Dumble, and at Barton Joyce by Dr. Sherlock, and influenced by faults at Thorneywood. The dip has been found to amount to as much as 50°. In the Melton area also the dip is thought to be influenced by "small undulations recognizable in the Lias", and between Moorhouse and Barrel Hill Mr. B. Smith noted disturbances following the direction of the dip, and the dip increases in the Gleet Valley, the rocks are gently rolling with the axis of the folds at right angles to the general strike of the beds. In the Ollerton district they have been noted in the waterstones at Rufford Park, and in the Red Marl an anticline trends through Muskham Wood and Eakring, while Goosemoor Dike is excavated along a syncline. Anticlines occur in the waterstones at Kirton Wood also, in the Red Marl synclines at Mather Wood and Kersall, anticlines and synclines at Bathleyford Bridge, Tuxford. It is thus plain that the undulations in the Trias are of pretty general occurrence. Whilst the flexures produced are largely due, as exposed at the surface, to river development and denudation, their original form was not unlike their present contouring. That these phenomena, when viewed in isolated instances as catenary bedding, cannot be attributed to sagging, is quite obvious when their relation to earlier foldings is recognized. It should also be remembered that apart from these undulations the general dip is south-east, and this was more or less original, whilst the existence of attenuation in some parts to the north-west, along the east outcrop, and in Cheshire, Staffordshire, and Warwickshire accounts for any supposed sagging, attributed to other causes.

The overlapping of the different members is shown in numerous instances, a fact which can only be accounted for by subsidences and deposition by aqueous agency. The Lower Keuper lies in hollows of the Pebble beds, both in the Mease Valley and in Notts, abutting against the ridges they form. The Red Marl overlaps the Lower Keuper, and both the Bunter. The Lower Keuper also overlaps the Permian. It is probable, moreover, that the surface

of the Coal-measures presented an uneven surface for the deposition of different members of the Trias upon it, being also attenuated to the south-east from the north and west, as seen from numerous colliery sections. This overlap is reflected in the discordance between the strike of the different members of the Trias.

Another feature is the gradual passage of the Lower Keuper Sandstones into the Marls, as noted at Austrey and Warton, and of the lateral passage of the sandstones into marls at Heather. This feature is paralleled in the Upper Keuper Sandstone by the thinning of the marls to the west and the sandstones to the east at Leicester, near Hinckley Road, and at Ashleigh House. In such cases we have instances of the occurrence of lenticular bands.

The river development of the Trias depends upon the fact that the main systems of drainage are developed along the line of strike (Caledonian in direction) of the Soar, excavated in the softer beds of the Red Marl. A similar feature is to be noticed in the Mease Valley where the valley forms the junction between the Lower Keuper Sandstones and Red Marls. No doubt the original systems of consequents and subsequents, with the resulting obsequents developed on a more ancient peneplain, is to a large extent modified as regards the Red Marl area in Leicestershire, so far as the present peneplain is concerned by the markedly radial arrangement of streams which are dependent upon the relation of the Red Marl to the old developed surfaces of Charnwood Forest. The developing of this area before the deposition of the Trias caused the system of drainage which largely contributed to the sediments forming the Trias and earlier rocks locally to some extent. The later development of the Red Marls since their deposition and formation of the present contours has been the work of numerous agents of denudation, subaerial in the main, before glacial time, which we have no means of determining. But glacial action itself has paved the way for much of the present system of drainage, causing radial arrangement of streams, together with the agencies that have regulated the present systems of consequents and subsequents upon which this radial system is superposed. In this way the river drainage west of the Soar Valley differs from that to the east except where, as around Billesdon, a similar radial arrangement may also be discerned in beds older than the Trias.

6. Petrography and Lithology.

As this section affords material for a separate paper, and, owing to reasons into which I need not enter, a bare summary of this even could not be prepared, I have decided to omit this section from the present paper. Reference to "The British Trias, a Delta System" (Trans. N. Staffs Field Club, vol. xlvii, pp. 100–30) will afford a very brief summary of the character of the sediments examined in this area, together with a comparison between them and the deposits in other parts of the country.

(To be concluded in our next Number.)

NOTICES OF MEMOIRS.

I.—The Art of Trephining among Prehistoric and Primitive Peoples. By T. Wilson Parry, M.D., F.G.S. Journ. British Archæological Association, pp. 39, with 11 figs., March, 1916.

DR. PARRY has long made a detailed study of the art of trephining the human skull, and now publishes an interesting summary of the whole subject. Skulls of the Neolithic period undoubtedly trephined during life have been discovered several times in France, but only one example possibly of so old a date has hitherto been met with in Britain. This is reported to have been found with remains of the Irish deer in peat at Port Talbot, South Wales. Two specimens which certainly belong to the Bronze Age have been examined by Dr. Parry, one from a cist at Mountstuart, in the Isle of Bute, the other from a long barrow near Bisley, Gloucestershire. Two other trephined skulls, one from Hunsbury Camp, near Northampton, and the second from the Thames, near Hammersmith, are probably of later date. These are the only examples of trephining hitherto found in Britain. It may be added that the Hammersmith skull has now been placed in the London Museum, where it is exhibited with an explanatory collection arranged by Dr. Parry.

II.—Record of a Prehistoric Industry in Tabular Flint at Bramdridge and Highfield, near Southampton. By R. E. Nicholas, F.L.S., F.G.S. pp. 92, pls. xli, text-figs. 8. Southampton: Toogood & Sons, 1916.

THIS beautifully illustrated little work by the Hon. Curator of the Tudor House Museum, Southampton, is a series of notes on a large collection of flints which the author has made at two localities near Southampton. The two sites are described, with explanatory diagrams, and the chief characteristics of each specimen are briefly enumerated. Dr. Robert Munro appends two pages of "Explanatory Notes", expressing the opinion that the working of the flints dates back to the transition period between the Palæolithic and Neolithic civilizations, which is already known by discoveries of similar flints at Cissbury, in the Oban caves, and in other localities.

III.—Upper Devonian Fish Remains from Ellesmere Land, with Remarks on *Drepanaspis*. By Johan Kiær. Report of the Second Norwegian Arctic Expedition in the *Fram*, 1898–1902, No. 33 (pp. 72, pls. viii, text-figs. 8), 1915.

THE fragmentary Upper Devonian fish-remains discovered by the late Per Schei in Goose Fiord, Ellesmere Land, have been exhaustively studied at Christiania by Dr. Johan Kiær, who describes them in this well-illustrated report. Only one specimen was obtained from the truly marine beds at the base of the series—a head-shield of a small new species of *Macropetalichthys*, named after its discoverer.

Numerous remains of the ordinary Upper Devonian fishes occur in the typical Old Red at the top of the series in association with fossil plants which have already been described by Professor A. G. Nathorst. Fragments of dermal armour of two new species of *Psammosteus* exhibit well the microscopical structure, of which fine illustrations are given. Dr. Kiær also describes for the first time the microscopical structure of the plates of *Drepanaspis*, which he shows to be closely similar to that of *Psammosteus*. He agrees with Bashford Dean that the dorsal and ventral surfaces of *Drepanáspis* are wrongly identified by Traquair, the one being mistaken for the other. A Coccostean fragment and typical remains of *Bothriolepis* are described, and several large scales are referred to a new species of *Holoptychius*. Dendrodont and Rhizodont teeth also occur. The illustrative plates, by a photographic process, are especially beautiful.

IV.—On the Generic Position of "*Asterolepis ornata*, var. *australis*", McCoy; with Description of a New Variety. By Frederick Chapman, A.L.S. Proc. Roy. Soc. Victoria, n.s., vol. xxviii, pp. 211–15, pls. xx, xxi, 1916.

MR. CHAPMAN shows that the so-called Asterolepid fish from the Devonian of Gippsland, Victoria, described in 1876 by McCoy, is really a Coccostean. A new specimen from the same locality seems to prove that it belongs to *Phlyctænaspis* or to a closely related genus. Other specimens represent a new variety in which the ornament is very dense, with smaller and more prominent tubercles.

V.—Notice sur la Nature de l'Organe Hélicoidal du *Helicoprion*. By A. Karpinsky. Bull. Soc. Ouralienne Sci. Nat. Ekatérinebourg, vol. xxxv, pp. 117–45, pl. i, 1915.

Helicoprion Clerci, n.sp. By A. Karpinsky. Bull. Acad. Imp. Sci. Petrograd, pp. 701–8, text-figs. 5, 1916. [In Russian.]

DR. KARPINSKY, who first described the remarkable spiral of Elasmobranch teeth, *Helicoprion*, from the Permo-Carboniferous of Russia in 1899, is still making valuable contributions to our knowledge of this fossil. He now describes new specimens from Krasnoufimsk, one of them not less than 350 mm. in diameter. He refers to Hay's discovery of *Edestus* in direct association with the cartilages of the jaw, and concludes that there cannot any longer be doubt as to the true nature of *Helicoprion*. The inner part of one new spiral seems to have been broken during life, Dr. Karpinsky thinks through shock. The teeth in the new species, *H. Clerci*, are thicker than usual, and exhibit a slight crimping or plication at the base. They are therefore interesting for comparison with those of the new English species of *Edestus* described by Dr. Smith Woodward at the last meeting of the Geological Society of London.[1]

[1] See Reports and Proceedings Geol. Soc., *infra*, p. 381.

REVIEWS.

I.—The Geology of the Lake District and the Scenery as influenced by Geological Structure. By J. E. Marr, Sc.D., F.R.S. 8vo; pp. xii, 220, with 51 illustrations and coloured geological map in pocket of cover. Cambridge: at the University Press, 1916. 12*s*. net.

EVERY geologist who is already acquainted with the Lake Country, or who is intending to visit it, will be grateful to Dr. Marr for the present volume. In this he has collected his numerous memoirs and addresses in the form of a connected narrative, and as he has also included the results obtained by previous or contemporaneous workers the book forms a complete epitome of what is known of the geology and physiographical development of the district.

The work is intended primarily for the student, but by printing in smaller type such details as are of special interest to the trained geologist the author has attempted to adapt it also to the requirements of the general reader. As a rule scientific books which cater for different classes of readers fail to satisfy either, but we think that the present author has succeeded admirably in his object. This we feel is due in the first place to his really intimate knowledge of the district, and secondly to his ability to place the essential facts in an interesting and attractive form, a gift with which readers of the author's work on *The Scientific Study of Scenery* are already familiar.

The book opens with a brief review of the pioneer work in the district, due honour being accorded to Jonathan Otley, the Father of Lakeland Geology, a charming portrait of whom appears in the frontispiece. After a brief summary of the general structure of the district there follows a description of the Lower Palæozoic rocks and of the structural changes which took place in the area after their deposition. In this chapter we have a detailed consideration of the nature of the folding, faulting, cleavage, and metamorphism which has affected these rocks. Three views are quoted in this connexion—(1) that the Borrowdale rocks are in reality older than the Skiddaw slates and brought into their present position by an overthrust boundary fault; (2) that the apparent succession is the true one and that the fault between the two groups is a thrust plane; (3) that the fault at the base of the Borrowdale Series is not an overthrust but a 'lay fault' associated with a thrust plane. The latter is the view advocated by Dr. Harker and the author, who conclude that the movement resulted in folds having a general E.N.E. and W.S.W. direction which were accompanied by horizontal movements producing the lay fault between the Skiddaw Slates and Borrowdale lavas and between the latter and the Coniston Limestone. These are accompanied by normal faulting, but also by horizontal movements along vertical planes or 'tear faults' with the production of 'shatter belts'. It is of interest to note that the

presence of these 'tear faults' was suspected by Sedgwick as long ago as 1831.

The intrusions of Devonian age in the district, namely those of Shap, Skiddaw, Eskdale and Wastdale, and Carrock Fell, and their metamorphic effects are then considered, and the subsequent erosion of some 30,000 feet of Lower Palæozoic rocks, regarding which the author remarks: "That this erosion affected the highest Silurian rocks indicates that it took place in Devonian times"; as, however, the oldest marine Carboniferous beds of the south-west of England are shown on p. 115 to be absent from the northern district the period of denudation may have continued into Lower Carboniferous times.

In chapter xiii a brief description of the Upper Palæozoic rocks which surround the Lake District proper leads to a discussion of the post-Carboniferous changes, and is followed by a description of the events which occurred between the time of the formation of the dome in Tertiary times and the Glacial period. This is followed by an account of the Glacial period, and the volume concludes with a short description of the post-Glacial changes in the district. These later chapters, which are chiefly concerned with the development of the present scenery of the district, will probably be among the most interesting to the general reader.

The book is fully illustrated with black and white maps and sections in the text reproduced from previous publications by Dr. Harker and the author, including a large-scale map of the Shap Granite and its associated metamorphic rocks, while an admirable coloured geological map on the scale of 4 miles = 1 inch, for which the author acknowledges his indebtedness to Dr. H. H. Thomas, is contained in a pocket in the cover. The only criticism we would make in this is that the upper beds of the Ordovician and lowest of the Silurian are represented by the same colour, so that there is no visible division between the two systems on the map. This was doubtless determined by the technical difficulty of dividing a very varied outcrop, while from a physiographical standpoint the Stockdale Shales and Coniston Limestone are closely associated in producing the Yendale Valley and similar depressions to the south of the volcanic massif. The book is further embellished by numerous half-tone photographs in the text, which have been well selected to show the leading features of Lakeland scenery.

This volume, which will henceforth take its place as the recognized authority on this area, is notable not only on account of its admirable detailed summary of what is definitely accepted regarding the geology of the Lake District, but also for the clear indications regarding the points which still require elucidation. With this volume before him the future worker ambitious of forging the remaining links in the chain of evolution of this fascinating region will indeed have cause to bless the name of the gifted author of the Geology of the Lake District.

II.—Contributions to a Study of Tertiary Polyzoa.

1. Contributions a l'étude des Bryozoaires fossiles, No. xiv, Bryozoaires du Stampien. By F. Canu. Bull. Soc. Géol. France, ser. iv, vol. xiv, pp. 147–52, pl. iv, 1914.
2. Les Bryozoaires fossiles des terrains du Sud-Ouest de la France, No. viii, Rupélien de Gaas. By F. Canu. Bull. Soc. Géol. France, ser. iv, vol. xiv, pp. 465–74, pls. xiv–xv, 1914.

IN these two papers M. Canu continues his investigation of the French Tertiary Polyzoa. In one he discusses the age of the Argiles de Gaas, and concludes that they are Rupélien (=Stampien), instead of Latdorfien (=Sannoisien) as hitherto considered. The Polyzoa contained in them had already been described by Reuss, and of the seventeen species obtained by M. Canu by washing 15 kilogrammes of the clay, fifteen had already been recorded by the former author. One new species is described and a new genus founded for one of Reuss' species.

The material of the other contribution was from the Marnes à Huîtres of Fresnes-les-Ruigis, of Stampien age, and is chiefly remarkable for yielding three recent species, from the occurrence of which M. Canu is led to the conclusion that "Les marnes à Huîtres de Fresnes-les-Ruigis paraissent s'être déposées par 20 ou 25 mètres d'eau au voisinage d'estuaires de petits cours d'eau".

III.—Mesozoic and Cenozoic Mactrinæ of the Pacific Coast of North America. By Earl L. Packard. Univ. California Publ. Bull. Dept. Geol., vol. ix, No. 15, pp. 261–360, pls. xii–xxxv, 1916.

THIS memoir is based on the study of a large number of fossil and living Mactrinæ from North American Pacific Coast regions between Mexico and Alaska, belonging to the Universities of California and Washington. The author adopts the taxonomic system proposed for these molluscs by Dr. W. H. Dall during 1889 and subsequent years, in which was emphasized the importance of the Pelecypod hinge-structure for purposes of classification. In discussing the various elements of the Mactrine shell attention is directed to its general shape, the position of the beaks, the type of the pallial line with its sinus, the muscle-scars, and the dental armature. Form-variation is illustrated by a series of 'graphs' showing ratios of lengths to heights. Contours vary from a trigonal to an elongate type, their many variations having been observed to exist within the limits of certain species, while others are much more constant. Systematic descriptions are given of the different species represented, under the genera *Mactra*, *Mulinia*, and *Spisula*, these being divided into a number of sub-genera and sections. Those species recognized as new to science include *Spisula brevirostrata* and *S. mercedensis* (Pliocene); *Mactra trampasensis*, *Mulinia pabloensis*, and *Spisula*

selbyensis (Miocene); *Spisula acutirostrata*, *S. merriami*, and *S. tejonensis* (Eocene); and *Spisula chicoensis* (Cretaceous). A distribution table, both geological and geographical, adds to the importance of this work, the species ranging from Cretaceous to recent times. The Miocene is referred to as "the period of the greatest generic and specific differentiation of the family", the older forms being fewer and relatively constant in shape. The author's able explanations of the taxonomy and phylogeny of this group of shells are rendered still more interesting by the excellent plate-illustrations which adorn the memoir.

R. B. N.

IV.—Stratigraphy and Fauna of the Tejon Eocene of California. By Roy E. Dickerson. Univ. California Publ. Bull. Dept. Geol., vol. ix, No. 17, pp. 363–524, pls. xxxvi–xlvi (chiefly Mollusca and views of localities) and text-illustrations (maps, sections, etc.), 1916.

THE author recognizes four faunal zones in the Tejon Group of California, which, in ascending order, are named the *Turbinolia* zone, the *Rimella simplex* zone, the *Balanophyllia variabilis* zone, and the *Siphonalia sutterensis* zone. Stratigraphical and faunistic details are given of these zones, maps of California being also introduced showing the probable extent of the Tejon sea during the deposition of the rocks containing the different zonal faunas. This Eocene fauna is said to embrace about 300 species, 25 of which range downward into the underlying Martinez Eocene, while 3 or 4 occur in the Oligocene beds above. The species are fully listed from the various localities of the region, while some 15 Pelecypoda and about 30 Gastropoda are described and figured as new species. As geological investigators rarely attempt zonal work on the Tertiary formations, the author deserves our congratulations on his discovery of well-defined zones in this group of rocks, which adds an interest and a greater accuracy to our previous knowledge of these deposits.

R. B. N.

V.—Faunal Studies in the Cretaceous of the Santa Ana Mountains of Southern California. By Earl Leroy Packard. Univ. California Publ. Bull. Dept. Geol., vol. ix, No. 12, pp. 137–59, with 1 map, 1916.

IN carrying out his researches on the Cretaceous faunas of the Santa Ana Mountains, the author recognizes relationships to those characterizing other Cretaceous regions of California, especially with the Chico fauna of Shasta and Tehama Counties, to that of the underlying Horsetown Series. Foreign affinities of the faunas are more difficult to trace, although it is stated that, according to F. M. Anderson, they favour the Turonian of Europe as well as resembling the life groups as found in the Cretaceous deposits of Southern India.

The geology of the district includes (1) a basement complex of Triassic age, (2) the Trabuco conglomerates, which are *non*-fossiliferous and said to be pre-Chico, (3) Upper Cretaceous (Chico Group), (4) Upper Eocene of Tejon, (5) lowermost Miocene of Vaqueros, (6) Alluvium of Pleistocene age. Three zones are recognized among the Cretaceous rocks of the region, the oldest being the *Actæonella oviformis* zone, above being the *Turritella pescaderoensis* zone, and then the *Tellina ooides* zone. Full lists of the fossils, which are chiefly of molluscan interest, are given, showing their distribution through the different zones.

R. B. N.

VI.—Fauna from the Lower Pliocene at Jacalitos Creek and Waltham Canyon, Fresno County, California. By Jorgen O. Nomland. Univ. California Publ. Bull. Dept. Geol., vol. ix, No. 14, pp. 199–214, pls. ix–xi, 1916.

THE fauna assigned to this horizon and as listed in the memoir embraces 3 species of Echinodermata, 2 Cirripedia, 49 Pelecypoda, and 29 Gastropoda, including the description and figuring of the following new species: Gastropoda: *Astralium arnoldi*, *Chrysodomus coalingensis*, *Fissuridea subelliptica*, *Murex perangulatus*, *Natica* (*Neverita*) *orbicularis*, *Trophon magister*, *Turritella nova*; Pelecypoda: *Mytilus kewi*, *Tivela trigonalis*. The author points out a close resemblance existing between the Etchegoin and Jacalitos faunas, the former having been recognized as of probably Pliocene age by Professor J. C. Merriam; hence it is considered that the Jacalitos deposits should be regarded as Lower Pliocene, although certain observers had placed them in the Upper Miocene.

R. B. N.

VII.—Fauna of the so-called Boone Chert, near Batesville, Arkansas. By George H. Girty. Dept. Interior United States Geol. Surv. (George Otis Smith, Director), Bull. 595, pp. 45, pls. i, ii, 1915.

THE rocks with which this memoir deals are of Mississippian age and therefore belong to the Carboniferous Series. Faunal relationships are traceable between the Boone Chert fossils and those of the Moorefield Shale of Arkansas, but not with the Boone Limestone as has been usually recognized by palæontologists. In a tabulated statement is given the species of the Boone Chert fauna and their occurrence in the Moorefield Shale (chiefly the "Spring Creek Limestone"). This fauna consists of Corals, Bryozoa, Brachiopoda (*Productella*, *Productus*, *Spirifer*, *Reticularia*, etc.), Pelecypoda (*Conocardium*, *Parallelodon*), Gastropoda (*Bembexia*, *Euomphalus*), Ostracoda (*Primitia*), and the following new species: *Spirifer martiniiformis*, *Martinia* (?) *pilosa*, and *Conocardium meekanum* var. *magnum* (= new var.).

R. B. N.

VIII.—Faunas of the Boone Limestone at St. Joe, Arkansas. Dept. Interior United States Geol. Surv. (George Otis Smith, Director), Bull. 598, pp. 50, pls. i–iii, 1915.

IT is pointed out in this account that the Boone Limestone includes all the Mississippian rocks of Northern Arkansas and Southern Missouri, comprising equivalents of the Kinderhook, Burlington, and Keokuk formations farther north, while the St. Joe Limestone forms the base of the Boone Series. The Boone Limestone fauna consists of Corals (*Amplexus*), Bryozoa (*Fenestella*, etc.), Brachiopoda (*Leptæna*, *Productella*, *Spirifer*, *Reticularia*, *Athyris*, etc.), Pelecypoda (*Cypricardinia*), Gastropoda (*Platyceras*), Cephalopoda (*Cœlonautilus*), Trilobita (*Brachymetopus*). The following are described as new species: *Polypora*, n.sp., *Hemitrypa*, n.sp., *Chonetes ornatus*, var. *arkansanus* (= new var.), *Productella semicostata*, *P. patula*, *P. millespinosa*, *Rhynchopora pinguis*, *Cypricardinia rugosa*, *Cardiomorpha orbicularis*, and *Brachymetopus* (?) *elegans*. The fauna of the St. Joe Limestone as observed at St. Joe is also described. It is composed of about forty species, including Corals (*Zaphrentis*, *Cyathaxonia*, etc.), Echinodermata (Crinoids), Bryozoa (*Fistulipora*, *Cystodictya*, *Fenestella*, etc.), Brachiopoda (*Leptæna*, *Chonetes*, *Productus*, *Productella*, *Camarotœchia*, *Shumardiella*, *Spirifer*, etc.), Gastropoda (*Platyceras*). The author has recognized as new species *Fistulipora rubra* and *Camarophoria simulans*.

R. B. N.

IX.—Bottom Control of Marine Faunas as illustrated by Dredging in the Bay of Fundy. By E. M. Kindle. *American Journ. Sci.*, vol. xli, pp. 449–61, 1916.

THIS paper contains some important considerations on the influence of environment with regard to marine faunas living on sea-bottoms, molluscan life being more particularly alluded to. A number of shells obtained from dredgings in the Bay of Fundy are tabulated, the species having been obtained from differently constituted sea-bottoms which are referred to as: Boulders and Sand, Boulders and Gravel, Black Mud, Sandy Mud, Rocky and Sandy bottom, etc. The author recommends the palæontologist, when using fossils for purposes of correlation, to "recognize and bear in mind the close relationship between the physical texture of the bottom and the kind of life living upon it".

R. B. N.

X.—Fossil Collecting. By E. M. Kindle. *The Ottawa Naturalist*, vol. xxix, No. 10, pp. 117–24, 1916.

THE author suggests a number of collecting methods when obtaining fossils for study purposes, emphasizing, of course, the importance of precise localities being attached to each specimen, and the particular bed of the section being noted from which the fossil was procured. The measurement of strata by means of a spirit-level clinometer is also recommended. Remarks are made on palæography, and suggestions offered that complete data should be furnished

regarding the physical features of the rocks in which the fossils are found. The essay supplies several more items of information on this subject which should be of interest to palæontologists.

R. B. N.

XI.—Brief Notices.

1. Mexican Geology.—The latest batch of Mexican geology was received in London in the middle of July. It consisted of the Boletin and the Parergones del Instituto Geologico de Mexico from 1913 to 1916. Of first importance is the Boletin for 1914, containing G. R. Wieland's "La Flora Liasica de la Mixteca Alta", with its atlas (1916) of fifty fine quarto plates. The Parergones to hand includes the whole of vol. v (1913–16), and is largely occupied with seismological records from 1911 onwards. In part iv (1913) are a variety of analyses of rocks and waters; part v (1913) deals with the water-supply of various Mexican cities; part ix (1914) is a catalogue of the Mexican rocks preserved at the Institute; and part x (1916) contains more water-supply papers.

2. Indian Geology.—Mr. C. de P. Cotter has produced a *Contents and Index to the Memoirs of the Geological Survey of India*, vols. xxi–xxxv (1884–1911), for which the cordial thanks of all geologists are tendered to him.

3. New Guinean Geology.—In Reports on the Collections made by the British Ornithologists' Union Expedition and the Wollaston Expedition in Dutch New Guinea, 1910–13 (2 vols. 4to, 1916 (Francis Edwards), price £10 10*s*.), vol. ii, Report 20, 1916, Mr. R. B. Newton reviews previous work on the island and then describes the Foraminiferal Tertiary Limestones. These limestones are full of *Lepidocyclinæ*, the large forms (*L. murrayana* and *L. insulæ-natalis*) and the small (*L. sumatrensis*), as in the Christmas Island rocks, and Mr. Newton regards them as indicative of the later part of the Aquitanian age. An excellent plate of photo-micrographic sections by Green accompanies the report.

REPORTS AND PROCEEDINGS.

I.—The Royal Society.

June 29, 1916.—Sir J. J. Thomson, O.M., President, in the Chair.

Among other papers read was the following, a summary of which was supplied by the author:—

"New Bennettitean Cones from the British Cretaceous." By M. C. Stopes, D.Sc. Communicated by Dr. A. Strahan, F.R.S.

The present paper describes two new types of well-preserved fructifications of *Bennettites* in Britain. One is that of an entirely new species from the Gault; the other is from a Lower Greensand specimen, diagnosed from externals by Carruthers, but not hitherto described.

The paper is presented in two parts: (1) the description of the new species; (2) the full description of the vegetative anatomy as well as fructifications of *Bennettites maximus*, Carruthers. Both specimens are well petrified, yielding excellent microscopic sections.

(1) The ovulate cone of the new species was procured by Mr. G. Walton, of Folkestone, and sent to the author among several other Gault 'woods'. It appears to have been relatively immense in comparison with other known cones of the group, having a diameter of 70 mm. or more, and 600 or more seeds in a single transverse section. The seeds are five-ribbed, very small (1·2 mm. diameter), fitting into interseminal scales which completely fused to form a hard external 'shell' to the complex fruit. The interseminal scales are better preserved than in other species and had a peculiar external 'plastid' layer. The various layers of the seed coverings reveal more exact details than are known for other species. Restorations showing the peculiar investing 'cupule' of the seed and also its diagrammatic section are given.

(2) *B. maximus*, Carruthers, is chiefly interesting as having bisporangiate cones. These are the first such cones discovered in this country, and are interesting in showing ovules at a very early stage in their development, not hitherto described. The peduncle is large, but the fertile part of the cone so small that it is cut in only one section in the series through the cone. The ovules are in an early meristematic state. A restoration is given showing the proportions of the parts and how they differ from more mature cones. The species differ from all other *Bennettites* in its vegetative anatomy, in having curious pitted 'transfusion' cells in pith, cortex, and leaf-bases, and in the peduncle and bract scales, and in appearing to be without the 'gum canals' prevalent in every other member of the family.

II.—Geological Society of London.

June 28, 1916.—Dr. Alfred Harker, F.R.S., President, in the Chair.

The following communications were read:—

1. "On a new species of *Edestus* from the Upper Carboniferous of Yorkshire." By A. Smith Woodward, LL.D., F.R.S., V.P.G.S. With a Geological Appendix, by John Pringle, F.G.S.

The new fossil described confirms the interpretation of *Edestus* as a row of symphysial teeth of an Elasmobranch fish. The row of eight bilaterally symmetrical teeth, fused together, occurs at the tapering end of a pair of calcified cartilages, which evidently represent a jaw. An imperfect detached tooth probably belongs to an opposing row. All the teeth are unusually large compared with their base, and the serrated edges of most of them have clearly been worn during life. As in the case of the American Carboniferous *Edestus mirus*, small Orodont teeth of the form named *Campodus* are scattered in the shale near the jaw. Markings on the *Edestus* teeth themselves suggest that they have been derived from the *Campodus* type of

tooth. The specimen, which represents a new species, was obtained by Mr. H. H. Freer from shale below the Rough Rock, in the upper part of the Millstone Grit, at Brockholes, near Huddersfield, and was presented to the Museum of Practical Geology by Mr. E. Crowther.

2. "The Tertiary Volcanic Rocks of Mozambique." By Arthur Holmes, B.Sc., A.R.C.Sc., D.I.C., F.G.S.

Until recently the district of Mozambique—geographically as well as geologically—was one of the least known of the East African coast-lands. During the seasons 1910–11 a prospecting expedition was organized by the Memba Minerals Ltd., and during the second season Mr. E. J. Wayland, Mr. D. A. Wray, and the author visited the country as geologists to the Company.

With the exception of a coastal belt of Cretaceous and Tertiary sediments, flanked on the west by later Tertiary volcanic rocks, the whole territory consists of a complex of gneisses and other foliated rocks, intruded upon by granites belonging to at least two different periods. From Fernão Vellosa Harbour to Mokambo Bay the junction of the sedimentary formations with the crystalline complex is a faulted one, and the volcanic rocks, now greatly dissected by erosion, are distributed on each side of the fault. The lavas are of post-Oligocene age, and are clearly the result of fissure eruptions, the feeding channels being exposed as numerous small dykes that penetrate the underlying rocks.

Throughout the area the prevailing lavas are amygdaloidal basalts, in which the chief amygdale minerals are chlorite, heulandite, and forms of silica. An andesite dyke of later date occurs near the Monapo River. In the north, near the Sanhuti River, picrite-basalt, basalt, phonolite, and sölvsbergite have been found, and related lavas occurring elsewhere in the area are tephritic pumice and ægirine-trachyte. Thus, there occur together, within the limits of a small volcanic field, series of both 'alkali' and 'calc-alkali' types of lavas. The 'alkali' series can be closely matched by the lavas of Abyssinia, British East Africa, Réunion, and Tenerife. The amygdaloidal basalts of the 'calc-alkali' series are similar to those of the Deccan, Arabia, and East Africa, and also to those (of late Karroo age) occurring in South Africa and Central Africa.

In all, ten analyses have been made, and the variation diagrams constructed from them support the view that each of the series was evolved by a process of differentiation acting on a parent magma. From the composition of the amygdale minerals (which are referred to the closing phase of lava consolidation), it is deduced that the parent magma of the 'alkali' series was rich in carbon dioxide, and undersaturated in silica; whereas that of the 'calc-alkali' series was rich in water and oversaturated in silica. The radio-activity of the lavas indicates that the depth from which the parent magma came was probably between 33 and 44 miles from the earth's surface. The boundary fault along which the lavas are aligned seems to mark a zone where pressure was relieved to an extent and depth sufficient to promote fusion.

Dr. A. Strahan, F.R.S., exhibited cores from borings in Kent, showing pebbles of coal embedded in Coal-measure sandstones. With the coal-pebbles there occurred a few partly rounded fragments of chert, and in one of these Radiolaria had been identified by Dr. G. J. Hinde. The chert resembled that which had been described from Lower Carboniferous rocks elsewhere. Its occurrence suggested that the sequence of strata had been similar in South Wales and Kent, and taken in connexion with the piping of the limestone surface at Ebbsfleet and the absence of Millstone Grit in Kent tended to confirm the view that there is unconformity between the Coal-measures and the Carboniferous Limestone in that county.

Mr. F. P. Mennell exhibited a geological sketch-map of the Northern Margin of Dartmoor.

He said that the central part of Devonshire was to a large extent a *terra incognita*, but, as regarded the fringe of altered Carboniferous rocks along the northern border of the Dartmoor granite, he had been led, in the course of observations originally concerned with the petrology alone, to the conclusion that there was a probability of being able to establish a definite order of succession. This was rendered possible by the occurrence of some well-characterized bands of rock, especially limestones and tuffs, which were exposed in every good river-section. It was true that almost everywhere overfolds, sometimes accompanied by thrusts, were to be detected, and tended to make the observer somewhat doubtful of his ground. Nevertheless, it seemed impossible to escape the conclusion that, as one approached the granite from the north, older and older rocks were met with, and the extremely continuous character of some of the beds seemed to show that, in spite of all minor disturbances, the general sequence could be trusted. The comparison of the different lines of section leading up to the moor showed them to be strikingly similar. The granite was, moreover, intruded all along at precisely the same horizon, and its direct offshoots never reached into the lower of the two important bands of limestone, but were confined to the altered shales at the bottom of the series, which afforded, where fresh, good examples of andalusite hornfels. The series, which extends from south of Sourton to Drewsteignton and perhaps right round to Doddiscombeleigh, appears clearly older than the shales which have been so carefully searched for fossils in the Exeter region by Mr. F. Q. Collins. These last are considered of Pendleside age, and nowhere contain any traces of limestone. The probability is thus indicated that the distinctly calcareous series under consideration may represent part of the Carboniferous Limestone.

It may be noted that, although there are a number of bands of epidiorite representing intrusions of dolerite roughly parallel to the strike of the sediments, the contemporaneous rocks are never of such basic character. The main band of tuff stretches from Lake, near Bridestowe, to beyond Sticklepath, and of the numerous well-preserved rock-fragments it contains, most are of rhyolitic or trachytic character, with some which represent altered andesites.

The next meeting of the Society will be held after the long vacation, on Wednesday, *November 8, at 5.30 p.m.*